

**INFLUENCE OF  
MOTIVATION, SCAFFOLDED KNOWLEDGE GROWTH, RACE AND GENDER  
UPON  
THE USE OF TECHNOLOGY FOR MIDDLE SCHOOL SCIENCE LEARNING**

by

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## DEDICATION

This body of work is dedicated to the members of my family who have helped me bear this burden for the many years it took to complete it:

- My wife, Kathleen Rubio, whose presence in my life graces it far better than I could ever deserve and without whose faithful and unwavering support this day would never have come;
- My children, Daniel Rubio, Julianna Slager and her husband Jeremy and their son Judah, Angelina Dickinson and her husband Matthew, Reuben Rubio III, Raquela Rubio, Miranda Rubio, and Alicia Rubio, for giving me cause to continuously thank God for you;
- My mother, Dolores Rubio, who has literally believed in me, comforted me, celebrated with me, and prayed for and with me since day one; and
- My father- and mother-in-law, Robert and Wanda Bowman, who have always accepted and supported me without question.

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- My grandparents y padrinos de bautismo, Alejandro con Clemencia Sanchez, who helped raise me, told me stories, kept the cholos away, and always reminded me that “they” could take everything away from me, but they could never take my education.

“But you must continue in the things which you have learned and been assured of, knowing from whom you have learned them.”

2 Timothy 3:14  
The Holy Bible, New King James Version  
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## ABSTRACT

The goal of this study was to unpack the role that variables such as motivation, scaffolding, race and gender played as one hundred 8<sup>th</sup> grade students, in a school and community environment that puts them educationally at-risk, sought to learn thermodynamics in a nine week unit, aided by a computer-based learning environment. A basic model for science learning was developed from the literature, with core components of prior knowledge, scaffolded knowledge growth, and motivational constructs. Interactions with the model from the race and gender of the students were also examined.

The components of this basic model were based on paradigms such as “knowledge as elements” for science learning, goal orientation and Sagor’s CBUPO for motivation, and Scaffolding Design Framework for scaffolding learning with technology. The curriculum design relied upon state standards and principles of Project-Based Science, while the technology environment used was ELabBook, a product of the Computer as Lab Partner project. The study employed a time-series repeated measures design. Multiple measures including tests, surveys, interviews, and assessments of student artifacts were used to triangulate towards the findings. Linear regression was used to identify key variables representing each component of the basic model, and correlations were used to highlight important relationships and suggest probable cause based on chronology.

Outcomes of the study include: a) giving credence to the basic model, b) identifying the four different aspects of scaffolded knowledge growth that contributed to learning, c) supporting

the idea that African-American students perform better in an environment more aligned to Black Cultural Ethos, d) illustrating that low science self-efficacy in female students is not necessarily enhanced by high achievement, e) suggesting that feelings of belonging and potency were the aspects of motivation found to contribute most to learning, with additional clarification needed about the motivational value of competition, and f) highlighting students' desire for stellar cognitive and visual interface performance of classroom technologies.

Chapter three of the thesis, which describes the curriculum design and classroom dynamics, will hopefully inform STEM initiatives such as ITEST Strategies that seek to blend core science learning with engineering problem-solving in a middle school classroom.

# CHAPTER 1

## INTRODUCTION

### Science Learning as a National Imperative

In 2005, a bipartisan group of federal legislators asked the Presidents of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine to prepare a report with 10 prioritized, concrete actions and implementation strategies that would help them draft legislation and policy to enhance American science and technology so that the United States “can successfully compete, prosper, and be secure in the global community of the 21<sup>st</sup> century.” (National Research Council, 2010, p. x). The Presidents created a task force of 20 leading members of the scientific, engineering, and medical communities to prepare a response. That report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, focused on ways to improve the country’s investment in research, development, and higher education while spotlighting weaknesses in business competitiveness and educational quality. The report was the basis for Public Law 110-69, passed on August 9, 2007 and known as the *America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act*, or *America COMPETES*.

By 2010, the Presidents of the National Academies decided that events in the country and around the world had changed sufficiently (certainly to the detriment of the original recommendations) that an update of this original report was necessary after only five years. The committee was reconvened to prepare this update, which was released in the fall of 2010 and named *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. In this new report, of all of the concerns about the outlook for American competitiveness that were mentioned, they stated that “the most pervasive concern was considered to be the state of United States K-12 education, which on average is a laggard among industrial economies – while costing more per student than any other OECD country ... in spite of sometimes heroic efforts and occasional very bright spots, our overall public school system – or more accurately 14,000 systems – has shown little sign of improvement, particularly in mathematics and science.” (2010, p.4)

Theirs is not a singular, alarmist concern. It is consistent with several independent findings about science education in the United States that have been reported since the mid-1990s.

The National Assessment of Educational Progress (NAEP) is a periodic assessment of student understanding in several core academic areas for grades four, eight, and twelve mandated by Congress in 1969. This periodic report is known as The Nation’s Report Card, and is conducted from within the U.S. Department of Education. In 2005, the assessment of student understanding in science in fourth grade showed statistically significant gains between 1996 and 2005 for all students, and for students who are White, Black, Hispanic, male, female, or who

have free or reduced lunch (Grigg, Lauko and Brockway, 2006). There was also an improvement in the gap between the scores of White and Black as well as White and Hispanic students. However, for eighth grade students there were no improvements by any of these groups or their comparisons except for the scores of Black students and the gap between students eligible for free/reduced lunch and those not eligible. Students of color are overrepresented among the group of students who did not achieve basic competency, and are underrepresented among the group of students whose achievement was beyond proficient. For twelfth grade students, overall scores decreased between 1996 and 2005 although the gap between White and Black students increased; all other group changes or comparisons were neutral. It may be taken as a sign of pessimism or optimism that the scores of younger students are improving while those of older students are staying the same or decreasing, but for the purpose of this thesis, the important finding is that the scores of middle school students have not improved during this time, and that students of color (other than Asian-American) continue to score lower than white students. Further, when discriminating the scores by the type of science subject (earth, physical, life), the scores for eighth graders in physical science have decreased while the other science areas have stayed the same.

The Programme for International Student Assessment (PISA) is a similar global, longitudinal study conducted by the Organisation for Economic Co-operation and Development (OECD) that measures scores every three years in reading, math, and science for 15-year old students in participating countries. Science achievement has only been measured in 2006 and 2009, with fifty-seven countries participating the first time and sixty-four the second time. The most recent PISA study also places the science scores of the United States in the “middle”



internationally, but shows a significant increase between 2006 and 2009 (OECD, 2010). This increase is attributed to improvement among low-performing students, as 24% of this country's students were low-performing in 2006 but only 18% were low-performing in 2009, a statistically significant drop. However, there was no change in the percentage of high-performing American students. So whatever gain is being measured probably cannot be attributed to a phenomenon affecting all students, but only one affecting low-performing students.

There is consistency between the results of the NAEP and PISA studies that American students as a whole showed no increase in science achievement or understanding in over a decade, but that students of color did show some improvement. One can only speculate why. One intervening effect is the federal No Child Left Behind Act (United States Dept. of Education, 2003). The National Research Council (2010, p.8) reports that in the 1990s, "ninety-three percent of United States public school students in the middle grades were taught the physical sciences by a teacher without a degree or certificate in the physical sciences." This situation might be rectified by the provisions of No Child Left Behind, with its immediate insistence that only highly qualified science teachers be placed in middle school science classrooms. But is it possible that using more highly qualified science teachers may have had its greatest effect in schools with a larger population of low-performing students, but did not result in an across-the-board improvement that would have been detected?

The Trends in International Mathematics and Science Study (TIMSS) is a global, longitudinal study of the math and science knowledge and skills of fourth- and eighth-grade students that has been implemented every four years since 1995 by the International Association

for the Evaluation of Educational Achievement. Nineteen countries, including the United States, participated in the first study of eighth graders in 1995 and the number has grown to forty-eight for the latest administration in 2007. Data from this study shows that the average science scores of the United States' eighth grade students are in the "high middle" of all countries and have decreased slightly but not changed measurably or significantly between 1995 and 2007 (Gonzales, 2009). Scores of Black and Hispanic students are in the "low middle" of all countries, but the gap between each group compared to White students has improved.

The Global Competitiveness Report is a rank order index of the economic competitiveness of over 130 nations in the world. It is produced annually by the World Economic Forum (WEF). The report ranks countries according to twelve "pillars" of economic competitiveness, which in turn are based upon 133 different factors. The 2010-11 report ranks the United States fourth overall in the world, a drop from second place in 2009-10 and first place for several years before that (World Economic Forum, 2010; World Economic Forum, 2009). The quality of math and science education is considered to be a competitive disadvantage with a global rank of 52, which was the lowest of any other factor that constituted the pillar of higher education and training, and was ranked in the bottom 25% of economic factors for the United States; any factor which a rank of less than 10 is considered a disadvantage.

These important national and international reports seem to triangulate towards the same basic conclusions:

- a) Science understanding among American students has not changed in over a decade, with any gains among younger students offset by the lack of gain in middle and high school students

- b) There is a persistent achievement gap in the scientific understanding of underserved student populations, either students of color or lower socioeconomic status
- c) Improving the state of K-12 science education, particularly among older students, is a critical concern for the future welfare and competitiveness of the United States.

### **The Role of Technology in Improving Science Learning**

The National Education Technology Plan (NETP) of 2010, called *Transforming American Education Learning Powered by Technology*, is a report prepared by the United States Secretary of Education and staff, mandated by Congress to be presented periodically to describe how the Secretary and Department of Education plans to promote increased student learning in multiple academic areas through the use of education technology and how to increase the access to and use of technology for learning in schools with underserved populations (United States Office of Educational Technology, 2010). The plan both states and outlines technology's role as "revolutionary transformation rather than evolutionary thinking" (p. ix) in the areas of learning, assessment, teaching, infrastructure, and productivity, and is emphatic about the need for change to take place now.

The NETP also directly addresses the national imperative in science learning described previously in three important ways. First, it states that education technologies that support design principles from the learning sciences should be researched, developed and implemented in local curricula and instruction. Second, while the plan calls for education technology to be used in any academic content area, it specifically encourages the use of technology to enhance learning in

content areas collectively known as STEM (Science, Technology, Engineering, and Mathematics). Finally, the plan strongly supports the use of technology to improve learning by those who have been “marginalized” (p. xvi) in educational settings, including students of color, students from low-income schools, and in the case of STEM content areas, females. The NETP generally promotes the role of technology in content area learning, noting that it facilitates the acquisition of factual knowledge or procedural knowledge, and that it motivates students to “engage interest and attention, sustain effort and academic motivation, and develop a positive image as a lifelong learner” (United States Office of Educational Technology, 2010, p. 17). These areas – learning in science, motivation, and learning by marginalized or at-risk students - form the basis for the questions addressed and the implications of this study, which will be discussed later in this chapter.

The 2010 NETP diverges from its predecessors in that it calls for technology to be used in direct instruction when it is consistent with what we know about how students learn. Previous national technology plans focused on the need to help students acquire technology skills as a stand-alone domain in preparation for a technology-rich workplace, or the development of technological infrastructure, or professional development to help teachers with technology integration. The NETP also helps provide a basis for funding of STEM initiatives that are meant to identify K-12 strategies and implementation models to help flesh out this transformative role for technology, of which one example is the Innovative Technology Experiences for Students and Teachers (ITEST, National Science Foundation, 2012). The role of technology in education was originally conceived as a communications or delivery medium, as noted in the sixth principle of the first national set of standards for teacher education, known as INTASC

(Interstate New Teacher Assessment and Support Consortium, 1992). Mention of the use of technology in the curriculum was confined to a support role, either to “drill” students and provide feedback with correct answers or to introduce historical or instructional content on new media such as digital audio or video (United States Senate Committee on Labor and Resources, 1994). The historic technology debate between Clark (1991; 1994) and Kozma (1991; 1994) was largely about whether technology was simply a way to deliver instruction or if it fundamentally affected instruction and subsequent learning.

Collins (1991) was one of the first to suggest the transformative role of technology in learning, stating that student use of computers in schools would make learning more constructivist because computer tools, learning systems, and simulations are inherently constructive. He suggested that the use of computer technology could be an agent of needed reform for school systems and an essential tool to the development of technology literacy on a widespread basis, with the potential for increasing the richness of student learning through more individual and rigorous instruction. Tinker (1996) presents a chronicle of twenty-two studies with both large and small scale of “some of the most convincing evidence for the value of computers to improve learning.” (p. v.), studies that largely utilized the concept of microcomputer-based laboratory (MBL) or computer-based laboratory (CBL). MBL or CBL involves the use of digital probes to measure data and a software interface that provides visual representation and numerical analysis of the data measured. Many others also report on generally positive degrees of success of the use of MBL to impact learning (Brasell, 1987; Linn and Songer, 1991; Nakhleh, 1994; Tinker, 1996; Casey, 2001; Krajcik, 2001; Krajcik and Starr, 2001; Novak and Gleason, 2001; Staudt, 2001; Wetzel, 2001; Marcum-Dietrich & Ford, 2002;

Metcalf & Tinker, 2003). Linn & Hsi (2000) summarize a fifteen-year study known as the Computer as Learning Partner (CLP) project, an MBL-based approach to science teaching and learning strategy that integrates constructivist principles with a more advanced type of software interface that also allowed for easy-to-create *simulations* of experiments by students and *scaffolding* of student knowledge acquisition by the teacher. The concept of the computer as a learning partner suggests a role for technology beyond that of a medium or even a tool. Quintana, et al. (2004), in proposing a theory of scaffolding design for the use of technology to support learning, also reflects on a wide variety of successful uses of technology (not just MBL) to improve learning.

Efforts to integrate technology into education began to formalize during this time as well. The International Society for Technology in Education (ISTE) published a set of standards for K-12 students and teachers that were meant to serve as performance indicators upon which state or district benchmarks could be built (ISTE, 1998). These standards blended the earlier aspect of technology as an instructional medium with its own domain of knowledge to this developing notion of technology as transformative when it interacts and affects learning in content areas. The United States Department of Education launched its wide-ranging Preparing Tomorrow's Teachers to use Technology program (PT<sup>3</sup>) in 1999, which was an eight-year initiative to provide grants to higher education institutions and educational non-profit entities to effect positive change in integrating technology into teacher preparation at a local, regional, or state level. States such as Michigan created technology plans that included adaptations of the ISTE standards with plans for assessment (Michigan Department of Education, 2006). Meanwhile, the ISTE standards were expanded to include teachers and administrators, and were revised (ISTE,

2007; ISTE, 2008; ISTE, 2009) to put more emphasis on the role of technology to inspire creativity and scaffold and assess teaching and learning with reduced emphasis on mere acquisition of technology skills. Interestingly, creativity was listed as a major competitive advantage for the United States (WEF, 2010). Finally, the 2011 revision of INTASC includes a role for technology in instructional practice, “to maximize and individualize learning, and to allow students to take charge of their own learning and do it in creative ways.” (Council of Chief State School Officers, 2011, p. 9)

However, in spite of these heady efforts, the 2010 NETP acknowledges that technology is still not being integrated into teaching and learning, which is why the current state is called “evolutionary” with full implication of an unguided and perhaps inefficient process that may take a long time to realize quantum change. Technology use has evolved over time, but it has not yet evolved into a transformative educational force in K-12 schooling. Fishman, Marx, Blumenfeld, Krajcik, and Soloway (2004) look at many localized successes of technology use and note that usability, scalability, and sustainability from local to more widespread use has been hindered by a lack of corresponding systemic reform in schools; for example, important constructivist aspects of teaching and learning that go hand-in-hand with the use of certain technological tools are not implemented into the curriculum or the classroom environment in order to preserve an existing structure or climate. They also note that if educational researchers understand and address technology issues at the student or classroom level, but fail to address these issues at the administrative level or link technology-influenced curricula with standards, a barrier to more widespread use will emerge.

For example, with a head of steam in the form of support from the research community and acceptance in mainstream publications, it would be logical to believe that in the year 2013, MBL would be in widespread use. While MBL does enjoy a reasonable degree of use in college science classrooms, this is not the case in K-12. A recent online conversation (<http://maculspace.ning.com>, 2010) among members of the Michigan Association for Computer Users in Learning (MACUL) sums up the best reasons why: excessive financial cost, lack of expertise and interest in using technology by teachers who are more interested in content than technology, and lack of time for teachers to invest professional development time to create a constructivist learning environment that is at odds with a perceived full slate of content expectations (Novak and Gleason, 2001; Wetzel, 2001) accompanied by preparation for standardized testing of isolated science knowledge (Krajcik and Blumenfeld, 2006; Southerland, Smith, Sowell & Kittleson, 2007) and public accountability of the results.

Collins and Halverson (2009) look back on the history of introducing technology in American education over the past century, and note that the basic educational model of a singular expert attempting to help students understand a wide breadth of knowledge that they may need to know in the future is no longer relevant. This is especially true if one of the roles of school is to prepare one for the workplace, as they note that in the workplace the worker uses technology to acquire knowledge or solve problems as the need arises, without having to rely on any one source. They conclude that the work environment has been transformed by technologies that provide user-control that allows customization of learning and promotes interaction with both content and other workers (learners). They then point out that in order to transform education, technology must be allowed to fulfill the same role in K-12 learning. In other words, if students



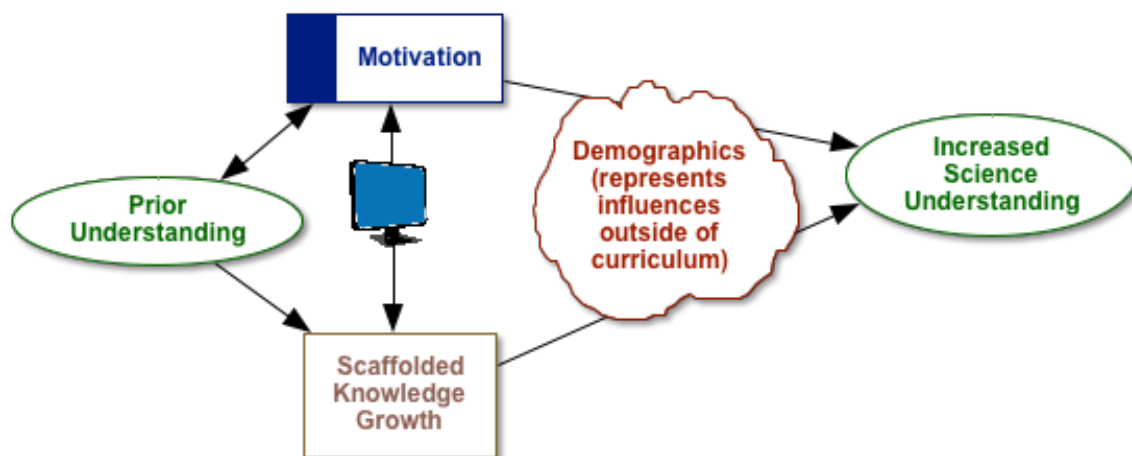
can use technology to learn in a way that is consistent with how The Learning Sciences say that they learn, then transformation can happen.

### **Research Study**

The purpose of this study is to explore the influence of technology on the areas identified previously from the 2010 NETP:

- 1) Student understanding of content, because any study of technology in a school setting has to measure this; in this case, the content area is science;
- 2) Student motivation; and
- 3) The performance of underserved students.

A basic model used in this study for student improvement in science understanding is illustrated in Figure 1. The independent variables that work together to increase science content understanding are a student's prior understanding of the subject matter, their motivation to learn, and the amount of scaffolded knowledge growth provided within the curriculum. The influence on motivation and the curriculum by the use of technology, in the form of MBL, is posited to be an important factor in stimulating motivation and effectively scaffolding knowledge growth; the characteristics of technology that are most important to both will be identified. Any effect on increased understanding from demographic variables such as race and gender, which are stand-ins for outside influences whose roots are social, cultural, and biological, will also be identified but determining any influences from specific roots is outside the scope of the study. Each of these components will be described more fully in chapters two and beyond.



*Figure 1: Basic model for increasing science understanding*

In the fall of 1994, planning began for a thermodynamics project for approximately 100 eighth grade students. The study was conducted during the winter 1995, beginning in January and ending in May. The school setting was a middle school in an urban setting whose student population was considered “at-risk” by most of the people who know the characteristics of this school - local administrators, teachers, other local educators, and politicians. This dissertation tells a story and provides an analysis of that project.

### *Relevance to the Research Literature*

The most direct connection from the findings of this study to the research literature comes from the 2010 NETP. The three research questions are based on areas identified by the plan where more information about the transformative role of technology in education is needed. Besides the plan, these findings cover areas where other researchers believe that more research is needed. For example, Roblyer & Knezek (2003) suggest studies that justify the costs of integrating technology-based learning such as MBL, or that address the motivational question

of structuring training, curriculum, etc. so that students or teachers are more interested in using technology in general – a motivational issue. Harris (2005) believes that new research that identifies contexts where learning technologies either are or are not suited to a learning environment is superior to the longstanding agenda of uncovering a turnkey technological solution that may not work in all situations. Roblyer (2005) adds that research is needed to “monitor the impact of learning technologies on important societal goals” (p. 198) like science learning and motivation of marginalized or disadvantaged students. The outcome of the study will suggest whether the use of technology improved science learning and motivation in at-risk students, and provide possible explanations why this took place or not. Blumenfeld, Kempler & Krajcik (2006) note that there remains a dearth of research on how technologically based learning environments motivate students. Another possible impact of this study will be to add more specific discussion of the influence of MBL technology use upon student motivation that uses the language of typical motivational constructs that are believed to enhance learning. Many previous studies of middle school or high school science classroom use of microcomputer-based laboratory talk about general effects upon motivation but do not study the contributions from specific constructs. Finally, with respect to the use of scaffolds in a computer based learning environment, Kim and Hannafin (2011) describe a need for understanding “which scaffolds support problem solving among students with limited prerequisite knowledge,” (p. 412) especially as it pertains to classroom use. When there are multiple embedded scaffolds, research is needed to identify the ones that appear to be most helpful to the students along with discussion of why they seemed to work best as part of a holistic learning system.

### *Student understanding of content*

The content focus for this study is an appropriate middle school subject, student understanding of the laws of thermodynamics, which includes the topics of heat and temperature. Thermodynamics is a subject area where the percentage of middle school students who demonstrate proficiency in their knowledge has a low absolute value. Linn & Hsi (2000) reported that over eight versions of CLP-based curriculum, “the percentage of student responses that matched a scientifically normative view” increased (ranged) from 12% to 49%, with the middle versions at 26-28% (p. 52). These middle versions roughly correspond to the version of CLP that was utilized during this project. Herrmann-Abell & DeBoer (2011) found that middle school students correctly answered 39% of questions related to conductive heat flow and 28% of questions related to conservation of energy. In absolute terms, these are low values, suggesting that there is much room for improvement and that ideas for how to improve are needed.

Roseman, Stern & Koppal (2010) state the importance of closely coupling the curriculum to content standards that provide coherence and interconnectedness of central ideas to optimize student learning as opposed to relying solely the content understanding of the teacher, which could be fragmented. The curriculum was aligned with the Michigan Essential Goals and Objectives of Science Education (MEGOSE) developed by the Michigan Department of Education (1991) which was in turn based on the national science standards described in *Science for All Americans* (AAAS, 1989). The curriculum was also connected with thermodynamics curricula used in well-known science education studies (Krajcik and Layman, 1988; Linn and Songer, 1991).

The framework for learning science is set against a backdrop of a conceptual change model with motivation integrated, and is based on key strands for learning science proposed by the National Research Council (2007). The environment supporting learning is primarily based upon the idea of project-based learning (Krajcik, Czerniak and Berger, 1999; Krajcik & Blumenfeld, 2006). Important curricular aspects of project-based science include a driving question that is open-ended, learning focused on the appropriate content, and students being asked to construct one or more key artifacts that require them to ask questions related to the unit content. The science content and technology used draws upon the Computer as Learning Partner program (Linn & Hsi, 2000). The science project would help them understand enough about thermodynamics (temperature and heat) to be able to address the “driving” question, "How do I keep hot things hot and cold things cold?" The key artifact would be for groups of students to each create, build and test an insulating device of their own design that would do the best job of reducing the temperature drop of a liquid across a fixed interval.

The choice of technology for this study is a classroom set of digital temperature probes using *ELabBook* as a software interface. *ELabBook* is the same interface used in the CLP project. It is a well-respected technology with a verified record of success (Linn, 1996; Stern, 2000; Linn and His, 2000) which is effective at scaffolding student learning by many aspects of the general framework suggested by Quintana, et al (2004). The scaffolds are embedded within the software to support both the core process of scientific investigation (“the scientific method”), to ease the acquisition and analysis of data, and to help the students develop causal reasoning skills stemming from reflection upon the data generated. It represents a high effort to use technology to increase science understanding.

The impact on learning is gauged by measuring the performance of students on pre/post tests of thermodynamics understanding, by assessing the results of open-ended interviews with a sample of students about heat and temperature conducted before and after the unit, by looking at their performance on lower stakes assessments such as a pop quiz and lab simulations and an investigation with *ELabBook*, and then by comparing all of those measures with the efficacy of the insulating devices built.

### *Student Motivation*

Pintrich, Marx and Boyle (1993) first proposed integrating motivation into the “classic” conceptual change model of Posner, Strike, Henson and Gertzog (1982). Blumenfeld, et al (1991), in originally discussing motivation within the context of project-based learning, cite the driving question, the generation of artifacts, and the use of technology as important motivational devices. Students see the question and the artifacts as giving purpose to learning, while viewing the technology as something to help them learn. This approaches the issue of motivation from goal theory. However, the motivational constructs of project-based learning later described by Blumenfeld, Krajcik & Kempler (2006) have some convergence with a general expectancy-value framework (Pintrich & deGroot, 1990), which is akin to goal theory but also accounts for how well the student thinks that he or she will be able to complete a task that they undertake.

The motivational constructs identified by Blumenfeld, Kempler & Krajcik (2006) include intrinsic value, competence, relatedness, and autonomy. Interestingly, this correlates well with Sagor’s perspective (1996; 2004) that, in the case of the at-risk student, motivation to learn is

stymied if the basic needs of competence, belonging (relatedness), usefulness (value), potency (autonomy), and optimism are not met. Thus, measurements of student motivation based on each of these five constructs are made before, during, and after the project used for this study. This will allow the data to speak to the research base for both project-based inquiry and the use of technology with at-risk students. The interviews mentioned previously were also employed to allow the students to provide insight into the motivational aspect of both the science learning and the technology. These measurements are made in order to help clarify the role technology plays in the science classroom and the interaction between two goals of student motivation, learning science and using computer technology. The measurements will also help identify any motivational barriers that existed; for example, Blumenfeld, Kempler & Krajcik (2006) warn that computer use can have a negative impact on motivation if the student feels inadequate to the challenge of grasping content and technology.

### *Performance of underserved students*

In both the literature and in this thesis, the terms “at-risk,” “disadvantaged,” “underserved,” “disenfranchised,” and “marginalized” apply to the same basic group of learners. For the sake of simplifying communication, the term “at-risk” will be used from here on.

Many definitions of the term at-risk may be found: Coleman (1966) long ago suggested that as long as there is an achievement gap between groups of learners, such as males and females or Black and Whites, then the lower-achieving group is at-risk. Pallas (1989) says that “young people are at risk, or educationally disadvantaged, if they have been exposed to inadequate or inappropriate educational experiences in the family, school, or community” while

Sagor (2004) broadens this to characterize 80% of at-risk students as "defeated and discouraged learner" (p.2). The Kansas Board of Education and many other government entities fund at-risk programs in schools based on the number of students who qualify for free or reduced lunch, i.e. they come from a low socioeconomic background (Kansas Department of Education, 2012), although there was some recent legislative action about redefining it to a student who fails standardized content tests (Myles, accessed 2/24/2011) which was ultimately defeated. The National At-Risk Education Network (NAREN, accessed 2/24/2011) defines an at-risk student as one who is "at-risk of dropping out of school or not succeeding in life due to being raised in unfavorable circumstances" and notes that "Students are placed at-risk when they experience a significant mismatch between their circumstances and needs, and the capacity or willingness of the school to accept, accommodate, and respond to them in a manner that supports and enables their maximum social, emotional and intellectual growth and development." Bulger and Watson (2006) also add in a deficiency in technological proficiency to the concept of being educationally at-risk.

Cole and Griffin (1987) point out that educators of minority and economically disadvantaged children - children who may also often be considered at-risk - "are pressured to 'do the basics better' and leave innovative educational practices to others" (p. 4). They note that many technology-based programs introduced or practiced in settings such as this one place an undue emphasis upon low-level cognitive "drill-and-kill" software rather than that which specifically targets higher-level thinking skills. These higher-order skills, defined by Bloom (1956) and again by Anderson, et al. (2000), correspond to the development of the type of science knowledge that students in the United States need the most, applying scientific



knowledge to a problem (PISA, 2006). When assessing the merits of an innovative educational program, classrooms consisting of "at-risk" students should be the lowest common denominator of success (Rubio, 1993), as too often innovative programs never make it to those students. In this project, all of the students utilized the same technology to develop standards-based content understanding, and the teacher and researcher attempted to engage their higher-order thinking skills equally; no distinction was made between groups of students. Of added interest, the MBL technology utilized in this study provided an innovative approach to scaffolding knowledge growth, and had not really been studied in a school environment such as this; this approach will be described more fully in chapter two.

For this study, the broader and simpler definitions of at-risk will be used. A statistical definition based on free or reduced lunch is easy to quantify, and this particular middle school's figure was 50% at the time of the study and is now 68%. In terms of overall academic performance, the school district ranks in the lowest quartile among all Michigan schools. The national and international science studies as well as the NETP identify an achievement gap between students of color and white students, and the science studies also identify a gap between males and females. Therefore, for the purpose of this dissertation, both black and female students are considered at-risk of not sufficiently achieving science knowledge or being discouraged from learning. Demographic information in the race and gender of each student in the study is tracked. All of the data generated as described above for both science learning and motivation will also be analyzed for variance by race and gender.

### *Research questions*

The specific research questions to be investigated are as follows:

- Did student understanding of thermodynamics increase, given this particular classroom environment, and high effort in the use of technology?
- What motivational or scaffolded learning aspects (as identified in chapter two) of the technology played the most important role in increasing understanding? Was the use of technology more academically motivating to the students?
- What were the interactions of race and gender upon content understanding? What features of the study, including the technology, more most beneficial or detrimental to underserved students?

According to the criteria listed by Campbell and Stanley (1963), the design of this study can be characterized as time-dependent, one-group, and pretest-posttest. A series of measures are taken of the students' preexisting condition. The students then undertake a project, a type of treatment. Finally, a series of measures are taken of the students' subsequent condition, in order to assess the effect of the treatment on the condition. Some of the measures are taken in the midst of the treatment, a scenario not specifically addressed by Campbell and Stanley. However, these administrations always proceed after the conclusion of an investigation, where the treatment consists of multiple investigations. Smith and Glass (1987) and Campbell and Stanley each warn of the many threats to internal validity inherent within such a design, namely history, maturation, testing, instrumentation, regression, and mortality. However, two important factors preclude a multigroup design for this dissertation.

Computer technology is believed to be capable of providing a student with a learning path that is fundamentally different than what might be attempted otherwise (Kozma, 1991), and with the help of embedded scaffolds can provide unique support of student learning (Quintana, et

al, 2004). The students use this technology to study simulations of physical phenomena. Computer simulations are intermediary between the symbolic and natural, with advantages such as speed and repeatability. Because of these attributes, it would be illusory to attempt to construct a standard experimental control group by attempting to create materials and curriculum to simulate the computer simulation, especially in a classroom where time and resources are finite (Tinker, 2001). After all, one of the major reasons for using a simulation is to help students learn while avoiding such time and expense. Furthermore, the curricular analog of replacing *scaffolded* technology such as that developed by the CLP group would be individual or group tutoring, a prohibitive option in this setting. Given that perspective, a multigroup design is not warranted.

A primary goal of classroom research is to help students learn. Watson (2007) suggests that if there were a version of the Hippocratic Oath for academia, one of its tenets would be to do no harm (e.g. do not exploit human subjects). With that in mind, it is important to do one's best to make sure that all students receive the researcher's best effort to help them learn, and not to disadvantage any student learning (even learning taking place after the study ends) for the sake of research methodology. The students directly involved in the research are the ones who will experience a first order effect of the intervention, making it important to accommodate the classroom culture as much as possible to promote continuity of classroom management during and after the study. The culture in this setting was one of uniform treatment of all; in the one instance where a deviation from this policy was made - some of the students were singled out for pre- and post-interviews - a discernable clamor about who was "smart" or "stupid" enough to be

chosen could be heard. Therefore, a uniform treatment philosophy was adopted for this study. Smith and Glass (1987) note that in such situations, the time series design is appropriate.

### **Summary**

The fundamental research question under investigation for this study involves a look at how technology affects science understanding and motivation towards science learning, especially within a context of an at-risk student population. A review of the literature that reveals more about the theoretical underpinnings of the study is presented in the following chapter. A description of the classroom and school, the curricular design for the unit, and an educational timeline and narrative of the project is provided in chapter three. The methodology is discussed in the fourth chapter. An analysis of the data is given in chapter five. The research findings and their contribution to the literature are discussed in chapter six, along with suggestions for future implications and explorations of the topic.

## CHAPTER 2

### THEORETICAL FRAMEWORK

This chapter contains a review of the theoretical underpinnings of the study. The research questions under investigation were stated in the previous chapter as follows:

- Did student understanding of thermodynamics increase, given this particular classroom environment, and high effort in the use of technology?
- What motivational or scaffolded learning aspects of the technology played the most important role in increasing understanding? Was the use of technology more academically motivating to the students?
- What were the interactions of race and gender upon content understanding? What features of the study, including the technology, more most beneficial or detrimental to underserved students?

In the previous chapter, a basic model for how to help students improve their understanding through the use of technology was presented in Figure 1. The basic model springs from conclusions drawn from the literature presented in this chapter: that a foundation for this improvement is the students' prior knowledge, and that the technology (MBL) used in this study was designed to scaffold the growth of knowledge and the development of experimental skills as well as to academically motivate the students. As these three influences work together, there may also be intervening effects based on the demographics of the students – their race and gender – that may stimulate, impede, or not affect the growth in science understanding.

Given this model, the review of the literature presented in this chapter provides some detail on the role played by prior understanding, scaffolding, motivation, and race and gender, but also reveals shortcomings in our understanding of how students learn science using technology that are addressed by the research questions posed for this study.

### **How People Learn**

In 2000, the National Research Council (NRC, 2000) published a summary of research literature that describes how learners of all ages learn. This functional history and encyclopedia learning brings together research from various branches of psychology, neuroscience, anthropology, and education in order to provide a unified framework for understanding how people learn. The goal of this project is help the nation develop a “high literacy” among those in formal learning situations; this literacy means being able to find and use information when needed, as opposed to the historic goal of education to provide a learner with all of the information that one may possibly need and the ability to remember it (Simon, 2000). In previous time periods when information sources were difficult to access and the types of information needed were more uniform, this may have been a reasonable educational strategy. In the 21<sup>st</sup> century and beyond when a wide array of information sources are readily available through technology but the need for more creative solutions to complex and ill-defined problems is greater, the literacy strategy not only makes sense but requires a transformation in how students are educated (Collins & Halverson, 2009).

The National Research Council (2000) summarizes the following three conclusions about how people learn (pp. 14-18):

- 1) “Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.”
- 2) “To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application,” and
- 3) A “metacognitive” approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

One of the objectives of establishing these conclusions is to codify the basic principles of learning that the most well-received research efforts have more or less converged upon for the past twenty to thirty years. A corollary to this is to communicate these principles to as wide an audience as possible, particularly to content experts, K-12 teachers and administrators, and teacher educators in higher education, government, and the private sector. A second objective is to encourage the development and use of synthesized sets of instructional principles that match the learning principles but are domain-specific and age-appropriate, with a similar corollary towards communication of findings. A third objective is to provide a basis for future research efforts that build upon this foundation to either fill in the details or extend knowledge of learning, including looking at the role of motivation in promoting learning and researching uses of educational technology that support the development and organization of knowledge according to models. (National Research Council, 2000)

## How Students Understand and Learn Science

A subsequent report by the National Research Council (2005) takes the learning principles described above and elaborates on how they would be employed in elementary, middle, and high school settings to support learning in social studies, mathematics, and science. A third report by the National Research Council (2007) goes even further, focusing on science learning and the design of instruction in elementary and middle school. Both of these edited books fulfill the second objective of the first NRC report.

With respect to the first learning principle regarding preconceptions, the National Research Council (2007) describes the formation of preconceptions about everyday phenomena – what we may call science – in infants, toddlers and preschoolers in the “naïve” areas of physics or behavior of physical objects, psychology or behavior of sentient beings, biology or behavior of the bodies of living creatures, chemistry or the transformation of objects, and cosmology or the behavior of the earth and celestial objects. This approach is patterned after that of the National Research Council (2000), which establishes early privileged domains in physical causality, biological causality, numbers, and linguistics. The Council notes that studies show that learners at this age show good scientific reasoning skills in areas such as causality, induction, and even symbolic reasoning. As these children progress into the elementary ages and enter more formal learning settings, if left to themselves students are likely to retain or increase their naïve conceptions (which the NRC refers to as “misconceptions” but are also called preconceptions) about phenomena. Bransford & Donovan (2005) describe the importance of knowing preconceptions and engaging the resilient ones through conceptual change strategies.



## *Preconceptions and Conceptual Change*

Smith (1991) states:

"Students bring with them to the study of science a considerable amount of knowledge, which they have developed from their interactions with the natural world and the cultural milieu in which they live. However, learning science is usually not just a matter of adding information and making connections. Students' prior knowledge is often inconsistent with the scientific knowledge that they are expected to learn" (p. 49).

The process by which what students are trying to learn comes into congruence with what they know is the essence of conceptual change. Ausubel (1968) posited an early process for conceptual change that differentiates between two types of subsumption of learning material. In Ausubel's view, all new learning is subsumed into what is already perceived; no new learning is stored in isolation in one's mind. This implies that learning is an evolutionary process, with change being viscous and continuous rather than quantized or catastrophic. This is because of the subsumption process, as the integration of all new knowledge with existing knowledge undergoes a type of negotiation process. In some cases, the new knowledge may drastically change the overall schema; in other cases, it may have little to no effect. Further, it implies that "about faces" in understanding of a particular concept may require multiple subsumptions - that students may need multiple exposures before they are able to make a conceptual change. Scardemelia and Bereiter (2006) refer to this process as "idea improvement" and note that improvement from preconception to an accurate or accepted conception is not necessarily linear. They cite an example of K-12 science learners who had a simple but confidently held understanding of gravity. The learners then reconstructed that view in the light of subsequent

learning and ended up with less confidence in their ability to know all about what gravity “is” even though they truly had a superior conception of gravity compared to where they began.

Posner and Gertzog (1982) critique Ausubel’s view for being evolutionary rather than revolutionary, noting that a conceptual change theory must account for a radical restructuring of schema, for reasoning by the student regarding any new understanding rather than just inference, and for consistency with non-scientific domains such as metaphysics. Posner, Strike, Henson and Gertzog (1982) suggest four conditions that must exist for conceptual change to occur, and that each of these conditions must be satisfied by the student’s changing conception (p. 214):

- Dissatisfaction with the existing conception, or a severe enough cognitive dissonance between the student’s schema or mental model of one of the naïve areas above and the phenomenon, behavior, or idea that they are sensing that they are willing to change modify or abandon that model,
- A new conception that explains what they are sensing must be intelligible, or something that the student can intellectually grasp. Certain analogies or metaphors are especially useful in helping this to occur, and are referred to as “bridges” because they help the student cross a boundary or obstacle of understanding (Clement, 1993; National Research Council, 2007). Vygotsky’s idea of a zone of proximal development (1978) also comes to mind in suggesting that the intelligibility of the new conception should be slightly above what the student understands;
- A new conception must be plausible, meaning that it can be accommodated into the student’s larger mental model of how the world works because there is consistency with other domains or schema in that model. Students may be aided with plausibility when they see consistency between their knowledge and that of someone they consider an expert;
- A new conception should suggest a fruitful research program, elaborated upon by Glynn, Yeany, and Britton (1991) to indicate that the new conception should have explanatory and predictive power for the student. This begs the need for allowing a student presentation or artifact to be a culminating piece of the process.

This model, and in fact all thinking on the process of conceptual change, was greatly enhanced by the suggestion of Pintrich, Marx & Boyle (1993) that motivational factors have some bearing on progression through the stages described by Posner, et al. For example, degrees of satisfaction are influenced by affect or value beliefs. The students' sense of intelligibility, plausibility and utility are affected by constructs such as self-efficacy, goal orientation, or self-regulative and learning strategies in the content area. Therefore for some learners, preconceptions and prior knowledge can be a barrier to learning if they are satisfied with what they know and are not motivated to change, while other learners with similar preconceptions and prior knowledge may be motivated to learn because they lack such satisfaction and develop a goal for mastery of the concept. This inclusion of motivational and social constructs is called a "warming" of conceptual change (Sinatra, 2005) and will be discussed again shortly.

The model of Posner, et al. (1982) was also critiqued by Smith, diSessa and Rochelle (1993) for being too focused on what students did not know or conceive of properly rather than what the students did know that could be used to build more accurate knowledge. From an instructional perspective, this model may be appropriate for conceiving of conceptual change on the level of a single idea, lesson or even unit plan, but is less satisfactory for engendering ontological change within students over a year or several years. However, one of the legacies of this model is the way it underscores the importance of listening to students' preconceptions (prior to instruction and learning) and thinking about how to account for them in learning. Conceptual change modeling has since evolved into two approaches called "knowledge-as-theory" or "knowledge-as-elements" (Ozdemir and Clark, 2007), which may also be differentiated as "coherent" and "fragmented" (Vosniadou, 2008). The elements/fragmented

conceptual change theory is ultimately what governs the work in this study, but the other is briefly explained because of its historical role in science education and the fact that there are still many educators and researchers that value it.

The “knowledge-as-theory” approach in science learning begins with the belief that as toddlers and preschoolers, humans develop framework theories or systems of coherent thought that incorporate propositional knowledge and reasoning that are domain-specific but not necessarily domain-transferable. These theories may be naïve in comparison to those of a content expert, but they are both coherent and subconscious (Vosniadou, Vamvakoussi, and Skopeliti, 2008). As humans mature in the elementary and middle school grades, they largely incorporate new understanding in these domains in three different ways, either by adding new knowledge to what did not exist before, by using new knowledge to fill in the details of the theories they developed previously, or by undergoing a conceptual change process when the new understanding is in conflict with their existing framework (Chi, 2008). When there is a conflict, they may resolve it by attempting to synthesize what they know with what is being instructed or observed, but this process may perpetuate rather than resolve naïve conceptions (Vosniadou, Vamvakoussi, & Skopeliti, 2008).

Within this model, forms of conceptual change include either a) easily incorporating new knowledge into an existing framework, b) having to restructure a mental model of an existing framework to accommodate the new knowledge, or c) undergoing a revolutionary ontological shift involving restructuring of schema and even a change in epistemology if necessary (National Research Council, 2007; Chi, 2008). This latter process may involve differentiation of existing

concepts into two or more descendants, or coalescence of two or more existing concepts into one, and may involve the transposition of either the role (central or peripheral) or character (property or relation) of the concept(s).

In contrast, the “knowledge-as-elements” approach may be thought of as a “bottom-up” conceptual change model with the same goal of developing coherence of knowledge. The comparison is reminiscent of the historical choice of distributed/connectionist (bottom-up) or rule-based (top-down) cognitive models to describe learning. diSessa (2006) describes a view of students’ naïve ideas as “fragmented so as to allow disassembling, refining, and re-assembling” (p. 268). Ozdemir and Clark (2007) suggest that these ideas are quasi-independent, are reasoned and applied consistently by the learner but are highly contextual rather than domain-specific, are revised and refined in an evolutionary manner over longer periods of time, and are explained contextually rather than as a theory or ontology.

Clark (2006) proposes a conceptual change process that emphasizes helping learners connect ideas and compare pre- and naïve conceptions with more normative ones, providing learners with repeated exposure to key ideas and providing opportunities for them to follow their own conceptual path to understanding as opposed to expecting to follow a unified approach. The term “knowledge integration” would summarize this type of conceptual change process. In the context of science learning, Linn and Hsi (2000) define knowledge integration as:

“The process of making sense of science that includes adding new ideas to the mix of views about a topic, linking and connecting new and existing ideas, sorting out the ideas available, reflecting on the ideas while solving problems, and restructuring views to achieve more coherence ... students link and connect the ideas they bring to science class to [science] experiments, everyday examples, firsthand experiences, ideas of other students, prototypes, and principles. Students

progress in knowledge integration by gaining more robust and coherent perspectives on a science topic” (p. 362).

Both Ozdemir and Clark (2007) and diSessa (2008) suggest that the “knowledge-as-elements” approach to conceptual change has proven more successful in supporting student understanding in research studies. Interestingly, cognitive scientists such as the Dreyfus brothers (Dreyfus, Dreyfus and Athanasiou, 1986; Dreyfus and Dreyfus, 2005) and Bereiter (1991) have long argued for a model of expert knowledge based on intuition or a subconscious coherence of multiple domain- or situation-specific experiences (making pieces coherent) rather than a rule-based or perhaps one might say framework-based model advocated by Newell and Simon (1972), Glaser (1989) and the descendants of their knowledge tree. The Dreyfus’ (2005) note that rule-based cognition can lead to competence but will fall short of expertise, which suggests along with Clark (2006) that both approaches to conceptual change may be put into practice but may lead to different results; one approach may be sufficient to produce *competence* (scientific literacy among all learners) while the other may lead to *expertise* (some learners actually becoming scientists).

### *Developing Competence by Doing Science*

The second conclusion about learning proposed by the National Research Council (2000) has to do with developing competence in an area of inquiry. In the area of science, the American Association for the Advancement of Science (1989, 1993, 2001) identifies content knowledge, process and inquiry skills, and also values and attitudes (“habits of mind”) as important building blocks and determinants of scientific literacy. To wit, Project 2061 defines science as a combination of domain knowledge and process that are intertwined, and then advocates for the

position that students learn science by doing science. Brown, Collins and Duguid (1989), in proposing the notions of situated cognition and cognitive apprenticeship, suggest that “the activity in which knowledge is deployed and separated ... is an integral part of what is learned (p. 32)” Bransford and Donovan (2005) note the futility of attempting to learn science through simplistic investigations where students follow “recipes for experiments” (p. 405) where the cognitive path leads through a well-worn path consisting of receiving step-by-step instructions, true facts, and questions leading to specific answers or outcomes that are never truly in doubt. By contrast they state, “students learn the [science] content by actively engaging in processes of science inquiry (p. 405). They also describe the key role of imagination and creativity in scientific inquiry, noting that engaging in a scientific inquiry process on a question of interest is more motivating than being assigned one. Duschl (2008) makes this same distinction by comparing an older paradigm of what one needs to *know* to learn science with a newer one of what one needs to *do* to learn science. Michaels, Shouse and Schweingbruber (2008) refocus on the idea of science as “practice” (p. 34) rather than inquiry to suggest a comparison with familiar aspects of practice – repetition towards proficiency, a habit of mind, and the use of knowledge within a domain to meet an objective.

The National Research Council (2007) describes four strands of scientific proficiency as the summation of research in science education that explains the basis for developing and measuring competence in science. The four strands are:

- “Knowing, using and interpreting scientific explanations of the natural world,”
- “Generating and evaluating scientific evidence and explanations,”

- “Understanding the nature and development of scientific knowledge,” and
- “Participating productively in scientific practices and discourse” (p.37).”

The National Research Council (2007) uses the term *strands* to evoke the analogy of a rope consisting of intertwined threads or strands. There is no presumption of linearity or staging; all strands are equally important and available aspects of science competence, and all are embedded with content and process. A specific task or activity may or even should overlap more than one strand. The strength of competence in one strand has a positive influence and correlation to strength in another.

The first strand is essentially a redefinition of what the National Research Council (1996) states in its *National Science Education Standards* as what it means to understand science. The scientific explanations should be centered in major organizing themes or models that can help students interpret facts and organize their ideas. For example, the Michigan Department of Education (1991, 2000, 2009) identifies four major themes in the area of life science as living things, heredity, evolution, and ecosystems, while AAAS (1993) identifies six themes in the same domain to be diversity of life, heredity, cells, interdependence of life, flow of matter and energy, and evolution of life. The underlying assumption is that learners must undergo processes of conceptual change to build upon and refine or better develop their early naïve theories in physics (including cosmology), psychology, biology, and chemistry. According to the National Research Council (2007), some changes are easier to accomplish because students see some new knowledge and are able to fit it into their pre-existing framework in one of the four areas. The new knowledge may be seen as filling in detail or gaps in a framework. However, encountering other new knowledge that does not easily mesh with an existing framework may necessitate a



reconceptualization of a framework, or in the more ontologically profound instances described by Chi (2008), a reconceptualization of several frameworks. This could be thought of as a domino effect of change.

The second strand involves learners developing the ability to create, measure, analyze, and draw conclusions from data. The National Research Council (2007) suggests that the nature of science itself has undergone fundamental change in the late 20<sup>th</sup> and early 21<sup>st</sup> centuries, becoming more of a dynamic enterprise that is data-driven with more global collaborative engagement and consensus (or lack thereof). The tools of inquiry are linguistic, numeric, rhetorical, and technological, and the inquiry itself stems from curiosity about the natural world and creativity in posing and answering questions (National Research Council, 2000). Bransford & Donovan (2005) also identify broad science inquiry skills such as experimentation, modeling, interpretation of data, and argumentation.

While it is possible to identify some broad skills, Ault and Dodick (2010) among others argue that there is no unified scientific method and therefore it is important to remember that skills such as experimentation, modeling, interpretation of data, and argumentation employ skill sets that are contextualized within a science domain, and are therefore diverse. For example, Dodick, Argamon and Chase (2009) distinguish between methodologies employed in the experimental sciences (physics, physical chemistry, organic chemistry) and the historical sciences (geology, evolutionary biology, paleontology), particularly in communication skills. Concepts such as space and time are quite different in each of these branches, and have different implications for what it means to do an experiment. McNeill and Krajcik (2009) suggest the

importance of science learning that accounts for both domain-specific and domain-general knowledge, and that support (scaffolding) for both are needed. The consequence for K-12 science learning is that both learning and assessment should account for inquiry tool sets that are both distinct and overlapping depending on which domain is the focus of learning.

McNeill, Lizotte, Krajcik and Marx (2006) note some of the difficulties students encounter in this learning strand with understanding how to work with evidence and how to reason on the basis of the evidence. The specific understanding learners need includes aspects such as: a) the logic of how evidence supports a claim, b) what qualifies as appropriate evidence, c) the domain-specific principles that connect evidence with a claim, and d) what it means to validate or invalidate a claim that is counter to what they believe. One of the ways to support these difficulties is to develop a learning progression based on core concepts in the domain.

The third strand has to do with the nature and development of scientific knowledge, with a strong emphasis on understanding the role of theories and modeling. Michaels, Shouse and Schweingruber (2008) simply refer to this as “reflecting on scientific knowledge” (p. 20), with a clear connection to the previous strand. Harkening back to the second learning principle established by the National Research Council (2000), theories and models serve as “skeletons” onto which students can organize or retrieve knowledge. The importance of identifying and using models is underscored by a long-held finding from research about expert learners that they solve problems by making conscious reference to deep conceptual structures (Chi, Feltovich & Glaser, 1981), or even subconscious reference (Dreyfus, Dreyfus & Athanasiou, 1986). These structures could also be called theories or models. Roseman, Stern & Koppal (2010) also describe the

importance of “a core set of essential and interconnected ideas and skills ... that could serve as a basis for making sense of observable events, making personal and social decisions, and learning more” (p. 47).

The National Research Council (2007) notes that there has been a tendency in science education to “overemphasize methods, often experimental methods, as opposed to presenting science as a process of building theories and models, checking them for internal consistency and coherence, and testing them empirically” (p. 182). Interestingly, position statements on middle school science instruction by the National Science Teachers Association (NSTA 2003; 2007) suggest that at least eighty percent of science instructional time be spent on laboratories or field investigations, with a definite emphasis on understanding experimental methods but no emphasis on the connection with theory and modeling as part of the laboratory process.

Duschl (2007) notes that less research is available about model-based reasoning than for the first two learning strands, but starts with the observation that science has evolved from dependence upon the sense perception and intuitive or imaginative ability of individuals to a data- and model-driven community of discourse. Lehrer and Schauble (2006) categorize four broad types of scientific models, suggesting that students learn how to operate with each of them as part of constructing scientific knowledge. The four categories are: a) physical or mechanical models, e.g. a scale or functional prototype, b) representational models, such as a drawing, c) syntactic models, which describe components and their relationships, such as an event tree or concept map, and d) emergent models based on probabilistic distributions, diffusion or even chaos rather than hard design principles. The National Research Council (2007) also suggests

that models can be epistemic, distinguishable along dimensions that vary from absolutist or relativistic (subjective or objective), or that vary from science as collecting facts to science as building and testing theories.

The fourth learning strand identifies a role for argumentation (a civil discourse in which learners define and defend their ideas and question those of others rather than a semi-violent exchange of contrary views) in science learning. This has long been a hallmark of the practice of science; Conant (1951) notes that

“The important fact which emerges from even a superficial study of the recent history of the experimental sciences (say since 1850) is the existence of an organization of individuals in close communication with each other. Because of the existence of this organization, new ideas spread rapidly, discoveries breed more discoveries, and erroneous observations or illogical notions are on the whole soon corrected. The deep significance of the existence of this organization is often completely missed by those who talk about science but have no firsthand experience with it” (p. 17).

The National Research Council (2007) notes that often in the science classroom it has been the teacher who does the talking, and that when students do talk it is to attempt to provide a correct answer rather than communicate, interpret, claim, or debate something that is previously unknown. The NRC also warns that students must learn the language and norms for discourse, which is evidence-based and precise, and not confuse scientific argumentation with a less mature form where any means justifies the goal of winning. Scardemelia and Bereiter (2006) point out that social discourse can contribute to knowledge building if the community commits to “progress in their shared understanding,” seeks “common understanding rather than merely agreement”, and chooses to “expand the base of accepted facts” (p. 102) even if it means giving

up what one or more individuals in the community believe. This will set a suitable climate for conceptual change.

Michaels, Shouse and Schweingruber (2008) refer to this strand as “making thinking visible.” While there are clear advantages for the advancement of the community’s science knowledge to making one’s thinking visible to others, within the context of learning there is also an advantage to making one’s thinking visible to self and to compare and contrast the thoughts of self and others. McNeill and Krajcik (2008) describe an instructional framework which explicitly focuses on supporting students’ ability to write arguments (they actually prefer the term “explanations” to avoid confusion with the unpleasant connotation of “arguments”). Students learn to make a claim, then how to find or create evidence to address the claim, then how to reason about how the evidence supports the claim. When they are involved in each of the three stages, their thinking is made visible because it is provided to the other students in the class. If the class then takes the time to critique claims, evidence, and reasoning, then students can take the feedback and refine their original work and resubmit it. Between modeling by the teacher and the higher achieving students, all of the students are able to solidify their understanding of the concept under study.

This set of strands on how students learn science establishes some ideas for how to support or scaffold that learning from within a curriculum, or within a technology. Some of the key ideas that emerge are helping students become facile with models or some other “big picture” representation of science concepts, involving them in scientific experimentation that helps them predict, test, and confirm or contradict their earlier ideas (rather than just do a lab that

consists of copying a set of instructions), and facilitating communication both in writing and orally that shapes and evolves their ideas. Each of these aspects of active learning puts more importance on the ability of a student to assess his or her learning while in process – in other words, metacognition. Metacognition as an area of importance in how people learn has received more attention from the research community in recent years, and has become a bridge that helps unite understanding of cognition and motivation. Research into metacognition also reveals a structure by which motivation can be defined and even measured, which is of keen interest in this study.

### *Metacognition*

Lee and Brophy (1996) define “a state of motivation to learn science when students engage in science tasks with the goal of achieving a better understanding of science and activate strategies for doing so” (p. 303), which also suggests a link between motivation and metacognition as the National Research Council (2000) defines metacognition as “the ability to monitor one’s current level of understanding and decide when it is not adequate” (p.47). Bransford and Donovan (2005) state that metacognitive learning for students occurs when they reflect on their role in inquiry, and monitor and critique their own claims as well as those of others. Efklides (2006) describes two aspects of monitoring known as metacognitive knowledge (mainly factual and analytical) and metacognitive experiences (mainly feelings and judgments), and a derivative aspect known as metacognitive skills which are more popularly known as self-regulatory skills. Operationally, metacognition is an important catalyst for learning when the learner develops an honest assessment of the adequacy of his or her knowledge about a concept or domain, and entertains self-regulatory strategies to improve that knowledge.

The research supporting the third learning principle proposed by the National Research Council (2000, 2005) that addresses the importance of metacognition and self-regulation was strongly influenced by the motivational enhancement to conceptual change proposed by Pintrich, Marx, & Boyle (1993). Sinatra (2005) notes that after the publication of this research in 1993, cognitive views of learning (including conceptual change) began to acknowledge the importance of “extrarational or ‘hot’” (p. 108) motivational constructs such as “mastery goals, epistemological beliefs, personal interest, values, importance, self-efficacy, and control beliefs” (p. 109). Pintrich (1991) suggested early on that constructs from both cognition and motivation needed to be integrated in a learning model, even as they were still differentiated as motivational, cognitive, metacognitive or self-regulatory constructs. Metacognition has emerged as one area where such integration has been taking place. The National Research Council (2007) identifies this motivational aspect of metacognition in the context of science learning, and groups some of these constructs into broader categories such as:

- ‘I Can Do Science’ (beliefs about oneself and about science),
- ‘I Want to Do Science’ (goals, values, and interest), and
- ‘I Belong’ (identity)

Interpreted through Efklides (2006), these broad categories would have variants for both metacognitive knowledge and experiences, and would provide feedback to engage the learner’s self-regulation ... or possibly disengage it. Efklides (2011) suggests that these variants may be relatively stable within a person as he or she moves from one learning situation to another (the “person level,” p. 7), or they may be less stable within a person and a task (the “task by person level,” p. 7). Perceptions of success or failure in the learning situations at either the person or task by person level then feed back to the other.

As an example of the first broad category, Duit and Treagust (2003) propose that successful conceptual change must be rooted in metacognitive beliefs about the nature of science, which may be interpreted to mean that a student should understand that the nature of science is for knowledge to build upon prior knowledge in the field and some discourse of science within the community. If a learner views science knowledge as dynamic, then he or she is more likely to recognize that there is always dissatisfaction with one's knowledge and is comfortable with resolving cognitive dissonance and plausibility. If a learner views it as static, then there will be reluctance to "give up" what one believes and yield to conceptual change. This suggests dialectic between the first and third learning principles, a connection made early on by Songer and Linn (1991). They hypothesized that if students believed that scientists regularly challenge their own and others' ideas, then they would be more inclined to do likewise, a dynamic view of science which would facilitate knowledge integration.

From a social perspective, Magnusson and Palincsar (2005) illustrate how metacognition is facilitated by small-group and community discourse by having groups of students report on the results of their investigations to the rest of the class. The students are asked to report the claims that they feel are most strongly supported by evidence, and to explicitly connect the question, the investigation(s), the results, and the conclusion(s). The community is then expected to evaluate each report and provide feedback to the groups, who then have opportunities for the groups to make refinements in their question, investigation and to provide updated reports and conclusions. Inagaki and Hatano (2002) note that an important condition for conceptual change is that the learner should be aware of an alternative conception, either one he thought of or one he was



presented with from somewhere (or someone) else. Furthermore, they point out that learners are less likely to ignore incongruities between what they know and what they are hearing if engaged in social interactions within a community for an extended time. The students described by Magnusson and Palincsar are aided in their learning by a metacognitive process similar to this.

The National Research Council (2007) suggests that discouraged or defeated learners, or learners who see their gender, race, ethnicity, etc. as an indicator that they will not be successful in learning science or that they belong in a community of science practice encounter a motivational barrier within the first and third broad categories. While there are not hard variations between gender, race, and ethnicity for the second broad category, these variables may account for some variance in conceptual understanding between otherwise equally capable students. In investigating the effects of race and gender in this study, measures of motivation related to these categories should be included, studied and explained.

### *Motivation*

For the purposes of this study, it is important to be able to take the body of research on motivation and distill a set of principles or constructs for all learners that can correlate to specific measures of motivation. This will allow the students' motivation towards science, technology, and the unit to be examined for change or influence as the technology is utilized and as the science is learned. It will also allow for examination of whether these constructs vary by race and gender within this study or remain the same for all learners.

Eccles (1983) proposes a general motivational model of connected expectancy and value based upon work focusing on gender differences in participation in higher order mathematics courses:

"The model itself is built on the assumption that it is not reality itself (i.e. past successes or failures) that most directly determines children's expectancies, values, and behavior, but rather the interpretation of that reality. The influence of reality on achievement outcomes and future goals is assumed to be mediated by causal attributional patterns for success and failure, the input of socializers, perceptions of one's own needs, values, and sex-role identity, as well as perceptions of the characteristics of the task. Each of these factors plays a role in determining the expectancy and value associated with a particular task. Expectancy and value, in turn, influence a whole range of achievement-related behaviors, e.g. choice of the activity, intensity of the effort expended, and actual performance" (p. 79).

The expectancy core concept embodies how well the student thinks that he or she will be able to complete a task that they undertake. In a classroom setting, this can be as narrow as an individual assignment or as broad as an entire year's offering. It is generally thought that expectancy is domain-specific. The value core construct reflects how important the student believes the task to be, and whether that importance is internally generated or externally imposed or presented. Value is clearly domain-specific, and can play an important role in classroom learning because task importance is often portrayed as ideally being internally-generated - ideal in terms of optimally promoting or allowing motivation.

Pintrich and deGroot (1990) describe three motivational constructs that address individual orientations, beliefs, and perceptions of classroom learning. The three are expectancy or self-efficacy (also known as perceived competence, attributional style, and control beliefs), intrinsic value (sometimes also described in terms of goal orientation and interest), and affect (most prominently anxiety but also, such things as anger, guilt, and pride). The first two are

derived from an expectancy-value theory of motivation, and the third is an extension of that theory. They speculate that anxiety appears to be the most important affective reaction in a school setting, although the other emotions mentioned also play a role. They include anxiety because research indicates that there is a relationship between affect and self-regulated learning, conclusions which have been affirmed by other researchers including Pintrich, Marx & Boyle (1993), Sinatra & Pintrich (2003), Eccles and Wigfield (2002), Sinatra (2005), and Efklides (2006; 2011).

Eccles & Wigfield (2002) describe major motivational models that come from a general expectancy-value orientation, which they put into four classes of theories that: a) focus on expectancy, b) focus on reasons for engagement, c) integrate expectancy and value constructs, and d) integrate motivation and cognition. For the purposes of this study, the important theories to remember are goal theories, which focus on reasons for engagement, and theories that integrate motivation and cognition because the “crossroads” between the two is metacognition and self-regulation. The latter has already been identified in the previous section as an important factor in student learning.

Goal theories of motivation (and their “cousins,” interest theories) are concerned with a student’s question about why she or he should engage in and complete a particular learning activity (Eccles & Wigfield, 2002). The idea of goal orientations towards performance/ego or mastery/task of learning has become widely accepted, as has the idea of performance goal orientations of approach and avoidance (Ames, 1992; Kaplan and Maehr, 2007).

Kruglanski (1990) addressed the mechanics of how goals motivate by proposing epistemic motivations as "needs for nonspecific or specific closure and the avoidance of closure" (p. 182). He speculates that such motivations derive from a cost-benefit analysis of end states which are desired and experienced, states which are reminiscent of the connectionist outputs earlier referred to as expected or intended and actual. In short, these motivations are goal oriented. When a match between desired and experienced is made, epistemic motivation is at rest; in turn, this state of rest "freezes" cognition, such that processes of hypothesis generation and validation are suspended. At this point, the student possesses no motivation for new learning. If a discontinuity remains between what is motivationally desired and experienced, then epistemic motivation is active, and hypothesis generation and validation proceed. In this state, the student possesses a motivation to learn.

Closure is defined as a desire for a match, and avoidance of closure (the antithesis) as a desire for discontinuity, or a preference to continue to investigate; such a desire is presumed to be need based. The construction of a learning artifact may be considered to be a type of knowledge closure. Specificity is defined as the search for one answer, while nonspecificity is the search for many answers. The perceived nature of that artifact - whether one type is considered exemplary and others subordinate or whether many possibilities are esteemed equally - determines specificity. The learning artifact may be considered to be nonspecific in the context of the whole class, although it may be considered specific in the context of the individual student or student group. Kruglanski suggests that closure and specificity are orthogonal, and notes that environmental features can stimulate each of the four possible outcomes. He also notes that the

level of prior knowledge may interact with these epistemic motivations. This is addressed in the next section in the discussion of motivation and the at-risk student.

In the area of science education, the National Research Council (2007) underscores the importance of students' seeing a reason to exert effort even if they believe they can succeed in doing science. Varied research in science education suggests the key role of goal orientation or interest in classroom studies (Anderman and Young, 1994; Blumenfeld (1992); Blumenfeld, Kempler and Krajcik (2006); Cognition and Technology Group at Vanderbilt (1990, 1992) and Lee and Brophy (1996). For example, in studying the learning of simple physics by college students, Linnenbrink and Pintrich (2002) suggest that the students with performance goals have a fear of appearing wrong before others and are not willing to change their prior beliefs, while the ones with mastery goals do not mind changing their beliefs in order to achieve the goal of mastery. They also were able to associate a mastery goal orientation with a more "refined" (p. 130) conceptual understanding. However, Meece, Anderman and Anderman (2006) report that no *body* of evidence strongly correlating mastery goal orientation and achievement has emerged, and that difficulties in measuring achievement and the influence of teaching goal orientations may explain this.

#### *Motivational constructs for all learners*

The very nature of the term "No Child Left Behind" (United States Dept. of Education, 2003) presupposes the important underlying assumption that all children can learn (Barr & Parrett, 2001; Sagor & Cox, 2004). If one accepts that assumption (which I do), then there is a corollary premise regarding motivation that all children can become motivated to learn. In considering the notion of an "at-risk" student, this motivational corollary should be kept in mind.

It is the essential perspective of Sagor (1996; 2004) that, in the case of the at-risk student, motivation to learn is stymied if the basic needs of *competence, belonging, usefulness, potency,* and *optimism* are not met [emphasis mine]. He defines the at-risk student as:

"Someone who is unlikely to graduate on schedule with both the skills and self-esteem necessary to exercise meaningful options in areas of work, leisure, culture, civic affairs, and inter/intra personal relationships" (2004, p. 1)

He also points out the affirmative tack, that if those five attributes (competence, etc.) *are* present then the at-risk student will develop a “resilience” (1996, p. 38) that will provide them the motivational power to withstand difficult external factors such as socioeconomic status (Barr & Parrett, 2001), powerful forces which are likely to carry them away from an education that will help them become productive and happy adults.

What Sagor calls attributes are reminiscent of what psychologists refer to as core motivational constructs. Blumenfeld, Kempler and Krajcik (2006) identify “four determinants of motivation and cognitive engagement” (p. 476) as value, competence, relatedness, and autonomy. Constructs such as expectancy, intrinsic value, and affect were discussed in the previous section of this chapter. If the logic of Universal Design for Learning is that accommodations for learning disabilities are also useful to aid learning by students who do not have special needs (Rose and Meyer, 2002), then there is a similar logic that says the consideration and study of motivational factors that can improve the learning of the at-risk student should be the same ones considered and studied to improve the cognitive engagement of all students. The aforementioned motivational corollary would be that all children *can* become motivated according to the same basic constructs.

Sagor & Cox (2004) suggest that up to 80% of the at-risk population in our classrooms are "defeated and discouraged learners", to be contrasted by others he describes as their counterparts, "highly *motivated* students" [emphasis mine]. It is this contrast that brings attention to the notion that conceptual change is hindered for an at-risk student due to poor motivation. The basic needs or feelings Sagor describes are derived somewhat heuristically, although conceptually based upon earlier work regarding the impact of unfulfilled basic needs upon motivation (Maslow, 1954). It should be noted that the theoretical framework underlying Maslow is from a different line of thought than that which underlies goal theory or expectancy-value theory. However, hearkening back to Pintrich's comment regarding focus on constructs rather than theories, it is Sagor's employment of constructs rather than grand theory that is of greater importance.

The importance of a feeling of competence is explained by noting that schoolwork and learning is as much a focus of a student's life as a job is in the life of an adult. There is a paradox implicit in combining this statement with that of Resnick (1987) who observed that instructed or "in-school" knowledge is contextualized within the classroom, and has not been accommodated or assimilated with natural or "out-of-school" knowledge built up outside of the classroom. The paradox is that learning in school is simultaneously perceived as important and not important. Sagor says that it would be difficult for an adult to be prepared for and be enthusiastic (motivated) about a regular job if they felt they were incompetent to perform it. So it may be with the student. The inclination would be to make a literal psychological withdrawal from the task. A feeling of competence may be equated with what in more traditional motivational

language is called self-efficacy, the construct itself rather than the theory (Blumenfeld, Kempler and Krajcik, 2006). Self-efficacy beliefs refer to self-judgments of a person's competency or ability to learn and meet specific goals in a domain (Bandura, 1982). Pintrich, Marx & Boyle (1993) suggest that positive self-efficacy can either promote or endanger conceptual change. On one hand, a student may have confidence in their understanding of a given topic, and thus resist assimilation of new knowledge because they see no need to accommodate it. On the other hand, students may embrace assimilation and accommodation of new knowledge because they have confidence that they can incorporate new ways of perceiving and thinking. Sagor would suggest a third hand, that a student would have no confidence in their understanding of a given topic, and would resist assimilation of new knowledge because they do not believe they are intellectually capable of accommodating it. A measurement of self-efficacy would be a useful gauge for a student's feeling of competence.

The importance of a feeling of belonging may be understood through a similar comparison. An adult who felt unwanted or unaccepted on a job would find it difficult to persevere in it. There is an interesting corollary here with the multiple goals perspective of Wentzel (1993; 2002). She suggests that students may pursue multiple goals in school (academic, social, personal), and that academic accomplishments depend in part on the joint and interactive effects of goals and other self-regulatory processes on subsequent behavior. Thus in any collaborative endeavor there is a component to motivation that is not academically focused. For certain grade levels, such as middle school students, one is hard pressed to say that pursuit of academic goals predominates. In fact, student motivation to satisfy social goals can enhance or detract from motivation to satisfy an academic one such as mastery of a domain. By her logic,



the pursuit of a social goal such as "belonging" can advance pursuit of a learning goal, especially when both goals are pursued within the same classroom or school. Blumenfeld, Kempler and Krajcik (2006) refer to this as a need for "relatedness (p. 477)." It may again be posited that the inverse can also be true, that a frustrated pursuit of a social goal can frustrate pursuit of a learning goal, especially when both occur under the same roof. Middle school students are especially motivated toward the pursuit of social goals. Thus, a feeling of belonging may be operationalized by simple daily attendance, given that such a student is willing to exercise the option to not be present either by skipping school, feigning sickness, etc. A powerful sense of belonging can compensate for a lack of other feelings on Sagor's list, therefore if one feels that they belong, they are present. If they don't feel that they belong, they are absent. A sense of belonging can also be described in terms of persistence. Either the student never involves himself in any sequence of tasks, or a contiguous lack of involvement in a subsection of the sequence is observed.

The importance of a feeling of usefulness is marked by the confidence that what one does has social significance - that it matters to others. For students, the feeling of usefulness may have a stronger symbolic than literal status. It is symbolic in that it represents a potential for future merit and literal in that it represents its present merit. But there is a more pervasive aspect of usefulness beyond what Sagor outlines, and that is a sense of whether the work being done is useful. Weiner (1992) suggests that human beings have an inherent hedonic bias such that in the event of task failure, directional attributions will be made towards external rather than internal sources. Because of this hedonic bias, a decrease in intrinsic value will precede any decrease in self-efficacy, meaning that a student will attribute failure to the fact that they weren't interested

in their work before attributing it to lack of intellect or talent. Intrinsic value would thus become a defining trait of this expanded view of usefulness. Blumenfeld, Kempler and Krajcik (2006) distinguish between a lower gain situational interest and a higher gain personal interest, and warn that “seduction” or trying to engender situational interest through exciting but non-academic activities will not necessarily transfer to students developing a more enduring personal interest.

The importance of a feeling of potency is described by Sagor as the dimension of causal attribution called locus of control. Blumenfeld, Kempler and Krajcik (2006) refer to this as “autonomy (p. 477).” In its essence, locus of control has two extremes: a sense that one strongly acts upon and a sense that one is strongly acted upon. The at-risk student will tend to feel impotent, that external conditions force his or her hand. Sagor suggests that a feeling of potency is represented by perseverance or persistence. Perseverance may be detected in a classroom by how completely the student finishes their work. In a previous study (Rubio, Krajcik & Canty, 1993) it was surprising to see how often students simply choose not to complete tasks they had been assigned, sometimes because they had no clue what to do and sometimes because they felt like doing something else instead. Based on that experience, there is something to be said about potency from the degree of task completion, given that the students have the greatest control of anyone over what they do.

Sagor points out that the importance of a feeling of optimism stems from student assessment of his or her past work. As Pintrich and deGroot (1990) note, an affective component can mediate the extrapolation of future performance from past. Wigfield and Eccles (1989) suggest that student anxiety is

"most likely to develop among those children doing somewhat poorly in school, who view their abilities as stable entities that they cannot change much, and compare themselves to others doing much better than themselves." (p. 168)

They also suggest that anxiety and "doing poorly" form a strong negative feedback loop for future learning, thus clearly making anxiety a factor in a student's feeling of optimism. Because of this, anxiety emerges from among other "hot" components (pride, guilt, anger, etc.) as a construct that will reflect one's feeling of lack of optimism because it is focused on future performance but based upon past perception. Self-regulative strategies also come into play at this point in helping to distinguish between two types of highly anxious students characterized by Benjamin, McKeachie, and Lin (1987). There are those who have good study habits and can master learning the content but are anxious about evaluation and those who have poor study habits and are thus duly nervous about an evaluation of their lack of mastery of the content. Efklides (2011) identifies self-regulation as an indicator of optimism, because there is a positive feedback loop between one's feeling of optimism or confidence and one's willingness to expend effort. This relationship remains true at the task x person level, which suggests that student self-regulation can differ for different domains or tasks. The student can be optimistic and "try" in one class or unit, or when engaged in one category of task even if they are anxious and "don't try" in others.

Sagor's list of feelings is reminiscent of a type of self-determination theory (Deci, Valerian, Pelletier, and Ryan, 1991) in that it postulates the existence of a small set of fundamental needs. The quest for satisfaction of these needs then motivates one's cognition and behavior. One of the "wildcards" which make the theoretical study of an at-risk student difficult is the role of one's prior knowledge. Marx, Pintrich & Boyle (1993) describe prior knowledge as

something that can either assist or hinder one's motivation for conceptual change. In the case of an older at-risk student, the lack of prior knowledge may present a similar conundrum. Deci, et al (1991) state that

"Negative feedback, whether interpersonally administered or self-administered in the form of failure, has generally been found to decrease intrinsic motivation by decreasing perceived competence, and some studies indicate that lowered perceived competence can leave people feeling amotivated and helpless" (p. 334).

It is easy to see that this negative feedback loop can lead to lack of learning, which in turn limits the amount of prior knowledge the student will possess when entering a new learning situation. By the time one is in middle school, several years of existing in such a loop can leave the student "at-risk" - with neither the self-esteem (self-determination, also self-efficacy) nor skills (prior knowledge) to exercise meaningful options. The motivational impetus for learning would then come from the strength of the connection made with intrinsic value or authenticity. However, it should also be remembered that intrinsic value is considered to be relatively stable and slow to change; if it is to be the motivational entry point, then it must soon be augmented with positive experiences along the lines of the remaining constructs.

One can look back and see how Sagor's list of feelings fit with certain core motivational constructs defined earlier. In fact, Sagor makes that connection explicit (1996). Feelings of belonging and usefulness relate to interest and value, and feelings of competence, potency, and optimism relate to perceptions of competence. Feelings of optimism also are related to affect. The five feelings also align well with the motivational aspects of science learning, "I can do science," "I want to do science," and "I belong," that were identified by the National Research Council (2007).

Weiner (1990) describes the importance of considering motivation when engaged in the study of learning, and the potential pitfall therein, saying:

"However, for the educational psychologist, the prime issue always has been how to motivate people to engage in new learning, not how to get people to use what they already know, which is a more appropriate issue for industrial psychologists. The study of motivation for the educational researcher thus has been confounded with the field of learning; indeed, motivation often is inferred from learning, and learning usually is the indicator of motivation for the educational psychologist. This lack of separation, or confounding, between motivation and learning has vexed those interested in motivational processes in education, in part because learning is influenced by a multiplicity of factors including native intelligence. This confounding problem can even be seen in the outline of Young, because he included knowledge of results, for example, among the determinants of motivation, yet it surely influences the degree of learning." (p. 618)

This confounding problem stems from an iterative feedback loop between motivation and learning. It will also be found that such confounding will be a part of the methodology and assessment of the outcomes of this study as well, and in fact in any study specifically involving student motivation in the classroom (Roblyer, 2005). Motivation mediates learning by conceptual change. The constructs involved in mediation are goal orientation, intrinsic value, self-efficacy, and control. Prior knowledge and collaboration each carry a two-edged motivational sword; they can affect conceptual change in a positive or negative manner. Knowledge that is perceived by a student as intrinsically valuable is knowledge that the student either readily sees or is ultimately convinced to see can be useful in an authentic, natural world context. Once the student perceives this, it is assumed that she will be motivated to engage in further study.

### Expansion of the Basic Model

Figure 2 shows an expansion of the basic model for improving science understanding by including the variables related to scaffolded knowledge growth and motivation that will need to be explored. They also define features of the learning environment, and the technology that matches the environment, which should be prominent. For example, a claim that technology is able to scaffold science learning means that the technology and accompanying curriculum should feature understanding models or “big picture” ideas, experimentation where the outcome is not known with certainty at the outset so that the students can be guided through a logical progression of learning that includes testing ideas, communicating their findings and letting that communication shape their ideas, and generally thinking about how they are learning.

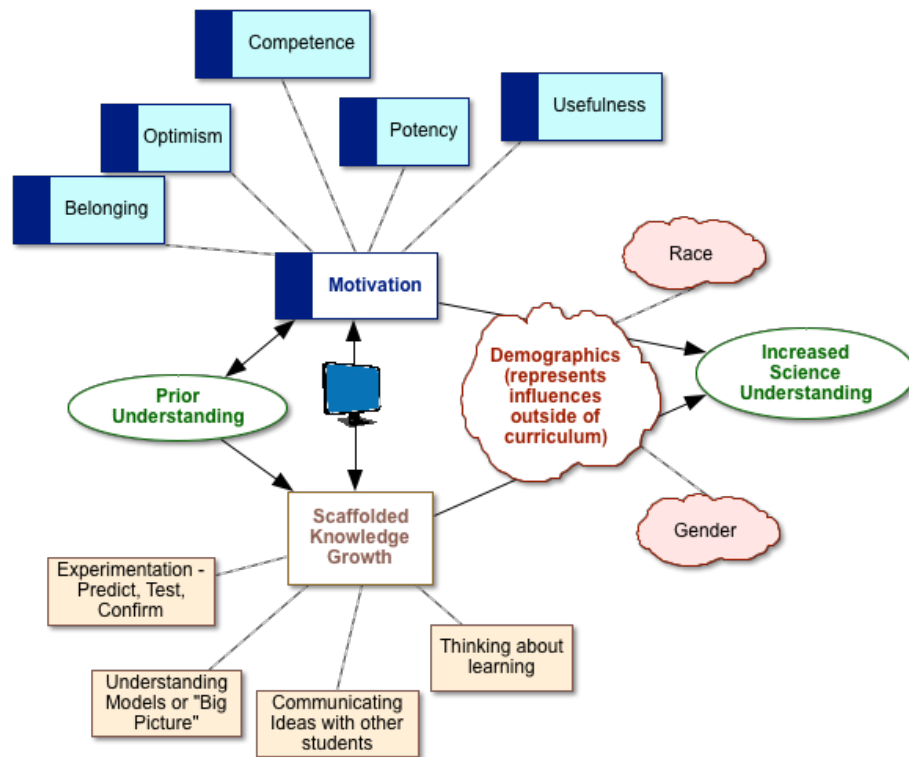


Figure 2: Expansion of the basic model.

The five feelings related to motivation can be explicitly studied, and correlations between these and aspects of knowledge growth discerned. The expanded model also highlights where each of these variables, along with effects from race and gender, may be analyzed to determine correlation and suggest probable cause.

The next section of this chapter addresses ways in students are supported in learning science, through the learning environment and through the specific use of technology tools.

### **Helping Students Understand and Learn Science**

#### *Learning Environment: Project-Based Learning in Science*

Project-based learning has a long history in American education, perhaps dating back to the early days of the United States and in popular use for over a hundred years after that (Hugg and Wurdinger, 2007). While there are numerous enactments of project-based learning, one that is of greatest interest in this research project is specific to contemporary science learning and based on the work of Krajcik and his colleagues (Blumenfeld, et al, 1991; Krajcik, Blumenfeld, Marx and Soloway, 1994; Krajcik, et al, 1998; Krajcik, Czerniak & Berger, 2002; Krajcik & Blumenfeld, 2006; Marx, et al, 1997). This learning environment, known as project-based science (PBS), is described by Krajcik, Blumenfeld, Marx & Soloway (1994):

Project-based science focuses on a driving question or problem around which central concepts within the curriculum can be integrated. Projects [are used to] build bridges between scientific concepts and principles and real-life experiences;

the questions and answers that arise in the daily experiences of students are valued and shown to be open to systematic investigation. Students work with others, use tools, and develop artifacts that represent their emerging understanding of ideas and problem solutions (p. 486).

Krajcik & Blumenfeld (2006) describe five essential features of project-based learning that were developed and examined in elementary and middle school science learning but may be generalizable to other subject areas. These involve students [emphasis mine]:

- Addressing a *driving question*, a problem to be solved;
- Exploring the driving question by participating in *authentic, situated inquiry*, which are processes of problem solving that are central to expert performance in the discipline (such as that of a scientist) through which they learn and apply important ideas
- Engaging in *collaborative activities* to find solutions to the driving question, mirroring the complex social discourse of expert problem solvers such as scientists;
- Engaging in an inquiry process with *scaffolding* (contextual, just-in-time help) *from learning technologies* to participate in activities normally beyond their ability; and
- Creating a set of *artifacts* (tangible products) that address the driving question, which are shared, publicly accessible and external representations of the class' learning (p. 318, ff).

Krajcik & Blumenfeld (2006) describe a cognitive framework for project-based learning that is based upon four major features: a learner actively constructing meaning based on his or her experiences, learning situated in a context and within a process that is authentic to science, social construction of knowledge, and the use of technology as a “cognitive partner” (Salomon, Perkins and Globerson, 1991) with the learner, holding a unique and indispensable role in propagating learning. The first three features of learning have essentially been discussed already in this chapter, and more will be said of the role of technology.



Project-based science supports the essential premise of conceptual change regarding accommodation and assimilation, as fastidiousness to standards is a key requirement yet does not mandate a particular enactment. Instead, a family of enactments is imagined which are highly dependent on the classroom context. Krajcik & Blumenfeld (2006) note that in the evolution of PBS, the curriculum materials that support learning need to become more generic to a given science classroom in order to support the important design aspects of project-based learning, with the hope that they are viewed as a family of model enactments rather than “cookbooks” or “teacher proof curricula” (p. 329). It is for this reason that the particulars of the classroom context play such a prominent role in the analysis of this study. Within PBS, a central tenet of designing a project is to construct a driving question that is authentic to science and interesting to the student. This question also serves as an anchor for conceptual organization of various concepts and sub-questions, and frames the practice of which the students are asked to make sense.

Blumenfeld, et al (1991) also present project-based science as a way of initiating and sustaining student motivation. They consider PBS to be motivational primarily because of the driving question and because of artifact generation, approaching motivation from the perspective of goal theory. The driving question revealed at the start of a project serves to help organize each concept or activity that the student approaches by giving it a purpose. From a cognitive perspective, it is an organizer; from a motivational perspective, it demonstrates a purpose, providing a way for the student to answer the age-old lament about schoolwork, “Why do I *have* to do this?” If the idea is to investigate a driving question that is authentic to the student, then

this effectively establishes an authentic purpose. The embedding of authenticity in the curriculum thus becomes an important factor in stimulating and sustaining student motivation. At the culmination of the project, the student creates an artifact that from a cognitive standpoint is a concrete representation of their knowledge. Motivationally, the artifact supports the notion of purposeful learning by allowing the students to aim for a defined goal or endpoint. Assuming that the artifact is intimately related to the driving question, the purpose that has been established throughout the project will be considered authentic if it interacts with the students' own knowledge and perceptions.

Project-based science is an ideal learning environment for the study described in this dissertation because it aligns well with key principles of learning highlighted by the learning sciences.

### *Learning Environment: Supporting Learning with Technology*

The National Education Technology Plan (2010) describes several ways in which computer technology can support student learning, by:

- Representing information through a much richer mix of media types (factual knowledge);
- Facilitating knowledge connections through interactive tools (factual knowledge);
- Providing scaffolds to guide learners through the learning process (procedural knowledge);
- Providing tools for communicating learning beyond written or spoken language (procedural knowledge);
- Fostering online communities (procedural knowledge);

- Engaging interest and attention (motivational);
- Sustaining effort and academic motivation (motivational); and
- Developing a positive image as a lifelong learner (motivational; pp. 15-17).

Of these, the characteristic of technology that most directly supports science learning in terms of the learning strands of knowledge and understanding of the natural world and understanding how scientific knowledge is constructed is its ability to scaffold, since scaffolding supports development of both factual and procedural knowledge as described in the NETP above. The National Research Council (2007) defines scaffolding as providing instructional guidance to students with a goal to facilitate learning. Quintana, et al (2004), describe scaffolding in relation to cognitive apprenticeship (Brown, Collins and Duguid, 1989; Collins, Brown and Newman, 1989) and the zone of proximal development (Vygotsky, 1978). With respect to cognitive apprenticeship, technology stands in for guidance normally provided from a mentor or expert problem-solver to provide just-in-time assistance (or opportunistically not provide it), approach complex problems, and facilitate collaboration, discourse, and presentation. With respect to the zone of proximal development, the technology embeds advice for student learning, contains multiple entry points to information or knowledge sources, or displays multiple representations of factual knowledge that are beyond the basic level of simply assigning or defining the task, so that the student is assisted with learning. Collins & Halverson (2009) provide examples of these ideas of how technology scaffolds learning that are commonly seen in the workplace and have also seen success with limited scope in K-12 classrooms.

Quintana, et al (2004), identify a Scaffolding Design Framework that suggests an approach for supporting science learners engaging in science inquiry within a computer-based

learning environment (Quintana and Fishman, 2006). The goal is to support student learning in the areas of: a) making sense of science content, practice and data, b) managing the learning process of approaching complex tasks, making informed decisions about what to do next, and using tools, and c) facilitating reflection and articulating rationales. Seven design guidelines for effective scaffolding are proposed, with each linked to three or four specific strategies, and examples of past or current technologies which exhibit these characteristics are identified.

The seven guidelines are as follows:

- 1) Use representations and language that bridge learners' understanding (making sense);
- 2) Organize tools and artifacts around the semantics of the discipline (making sense);
- 3) Use representations that learners can inspect in different ways to reveal important properties of underlying data (making sense);
- 4) Provide structure for complex tasks and functionality (process);
- 5) Embed expert guidance about scientific practices (process);
- 6) Automatically handle nonsalient, routine tasks (process); and
- 7) Facilitate ongoing articulation and reflection during the investigation (reflection; p. 345).

Embedded within these guidelines are both the necessary aspects of scaffolded knowledge growth outlined in Figure 2 and specific ways in which technology can be a cognitive partner to the student as suggested by Salomon, Perkins & Globerson (1991), who stated:

"the partnership with computer tools entails the three major ingredients one finds in human partnership: (a) a complimentary division of labor that (b) becomes interdependent and that (c) develops over time. Moreover, the partnership is genuinely intellectual: as defined by the concept of intelligent technology, the tool assumes part of the intellectual burden of information processing." (p. 3)

Besides scaffolding the development of factual and procedural knowledge, the NETP (2010) also suggests at least three ways that technology engages student motivation: engaging interest and attention, sustaining effort and academic motivation, and developing a positive image. Blumenfeld, Kempler & Krajcik (2006) note that technology promotes interest and attention because a) it provides students with access to information sources and representations of knowledge about a subject that are *authentic* to what professionals in that particular field of study use, and b) the students are able to control their own access to that information or those representations. This characteristic of authenticity is considered a notable feature of project-based learning as well (Blumenfeld, et al, 1991). The importance of authenticity in motivating students also contributes to helping the students develop a positive image as a lifelong learner because they see themselves as able to think like that professional. Collins & Halverson (2009) support this line of thinking in pointing out that ongoing access to authentic information sources reduces perceived differences between in-school and out-of-school learning, allowing a student to see herself as more than just a student, especially in a broader social context. Brown and Adler (2008) provide another example of this by pointing out the numerous instances of informal social learning from online discussions occurring away from school.

Blumenfeld, Kempler and Krajcik (2006) also imply that technology helps sustain effort and academic motivation by the implementation of the scaffolds described earlier. These scaffolds help the student control the pace of their learning so that in a sense they define their own progression of proximal development. With the increased level of scaffolding there can come a proportional decrease in locus of control - in the range and scope of choices available.

This begs the question of whether a motivational "relative maximum" appears in the relationship between learning support and the offering of choices. Malone and Lepper (1987) support the notion of such a maximum, noting that excessive choice devalues any motivational advantage and can lead to indecision and frustration. They also note that choice motivates more strongly when wielding it exerts a great deal of power, as defined by the size of the difference in outcomes stemming from making choices (or watching others make them). Tognazzini (1992), in talking about software interface design, suggests that if a given environment is designed with simple, stable principles, one may more easily traverse and create within that environment than if the principles were either numerous and complex or nonexistent. The same would be true of embedded scaffolds.

#### *Learning Environment: Microcomputer-Based Laboratory*

For the purpose of this research study, the specific technology under focus is microcomputer-based laboratory (MBL), also sometimes known as computer-based laboratory (CBL) or as a variant called calculator-based laboratory (also CBL). This technology may be considered a good representative of scaffolding technology because at its most basic level it incorporates several of the scaffolding guidelines listed above, such as organizing tools and artifacts around the semantics of the discipline (doing science like a scientist), using representations that can be inspected in different ways, and automatically handling routine tasks. It is important to note that MBL extends to technologies and formats beyond "microcomputers," as noted by Tinker (2001). MBL also implies a family of mobile or desktop computer-based technological tools used for data acquisition, visualization, simulation or modeling, and analysis

(Norris and Soloway, 2004). The tools consist of hardware and software, the software being either computer-based or internet-based, Web 2.0.

Thornton and Sokoloff (1990) describe a family of MBL tools with digital or analog probes which measure physical quantities like displacement, temperature, and sound pressure. Though originally developed for the Apple II computers, the software and hardware have been regularly updated during the last two decades so that they have always been compatible with the kinds of computers or mobile technologies used in schools. Probes are also available for measuring additional quantities such as force, light intensity, ionizing radiation, dissolved oxygen content, gas pressure, pH, respiration, and blood pressure. The probes may deliver either an analog or digital signal to an interface box, which contains a microprocessor and other circuitry which amplifies and converts that signal into a data stream that is sampled by the desktop or portable computer. Software is then written for that computer which displays the data stream in graphical or tabular form and also allows the user to perform real-time or post-hoc operations on the data. The students are thus able to simultaneously witness a physical phenomenon and a graphical representation of the data used to quantify it.

Thornton (1987) provides a description of what may be considered "first generation" MBL software, initially developed and distributed by the Technical Education Research Center (TERC), Tufts University, and Dickinson College, and later by Vernier Software. He states:

"The software is tool-based and user-controlled; that is, it makes it easy for the user to take measurements but does not tell the user what measurements to take. On the one hand, students do not have to know anything about computers to use MBL, because the menu-driven software makes their use self-explanatory . . . On the other hand, although the software is self-explanatory, it does not automate the student out of the learning process. The student remains in control" (p. 233).

The software was designed to maximize computational capability and graphical display but contained little in terms of pedagogical scaffolding. The teachers who designed the curricula and the students who used the software were provided with a tool that would measure and display data extremely well. However, no attempt was made to guide them into an understanding of the physical processes at work. Instead, that was left for a lesson plan and assumed to be part of the teacher's pedagogical content knowledge and/or part of the student's content knowledge.

This first generation MBL, given the practical limitations noted in chapter one, is in use in K-12 and higher education science classrooms today. However, Marcia Linn and numerous colleagues organized a larger effort known as Computer as Lab Partner around a prototype for a second generation of MBL that was more purposeful in scaffolding the learning process and helping students articulate the science (Linn, Layman and Nachmias, 1987; Linn and Songer, 1991; Lewis, Stern and Linn, 1993; Linn, 1996; Linn & Hsi, 2000). The Computer as Lab Partner (CLP) curriculum and the prototype known as ELabBook are described next because CLP was used as one of the classroom curriculum bases for this research, and ELabBook was the enactment of learning technology employed. The CLP curriculum is well aligned with four strands of learning science and fits well with a project-based science structure, and the technology adds scaffolding in areas not addressed by first generation MBL. ELabBook is an example of a broader type of education technology called a Computer Based Learning Environment (CBLE).



### *Learning Environment: CLP and ELabBook*

The Computer as Lab Partner (CLP) curriculum (Linn & Songer, 1991) was designed with an analysis of the needs of the students in mind, with questions such as "what is an important science concept to learn?" and "what would be appropriate cognitive demands for students who are attempting to learn this concept?" Lewis (1991) notes that the CLP curriculum assumes a constructivist view of learning, that students' existing knowledge influences and shapes subsequent learning, that new knowledge must be integrated with existing knowledge in order to be "learned", that the encouragement of student reflection and metacognition is a tangible goal, and that overarching principles of content or process are useful in structuring the manner by which students integrate knowledge. As noted earlier in this chapter, the CLP curriculum is aligned with the "knowledge-as-elements" approach to conceptual change because students are assumed to need support in integrating knowledge from disparate or uncertain ideas into coherent relationships (Linn & Hsi, 2000) on the basis of personal relevance.

An early important decision made by the CLP developers was the choice of a science content area. Linn & Songer (1991) describe criteria for content that include "an important topic familiar to students, readily encountered in natural settings, appropriate for middle school, and amenable to available technology" (p. 886). A content area that is readily encountered in natural settings will more readily allow students to tap into their prior knowledge, and facilitate experimentation and subsequent discussion about ideas. Linn and Songer note that thermodynamics was chosen because it met each of these criteria and also because it is fundamental to much of physical science, students readily encounter many naturally occurring

problems involving thermodynamics, and thermodynamics involves many observable influences which may be readily investigated experimentally.

These aspects of thermodynamics also lend themselves to the type of authentic exploration encouraged by project-based science. Initially in CLP, the study of thermodynamics was focused on the second law and on the differentiation between heat, heat energy, and temperature. Other formulations of the CLP curriculum are focused upon energy forms and conversion, where heat is but a player alongside light and sound (Stern, 1994). The rationale for this change is to provide students with a more holistic view of energy and both laws of thermodynamics.

Having chosen the content area, the cognitive goal of CLP proposed by Linn & Songer (1991) is to "encourage students to construct an integrated view of thermodynamics based on the mental model or models provided" (p. 889). Undergirding the early CLP agenda was a search for appropriate and reasonable cognitive demands to make upon middle school students to help them learn thermodynamics. Songer (1989) notes that students appeared unable to successfully integrate instructed knowledge with their existing knowledge consisting of preconceptions and personal theories about heat, hence the need for the scaffolding built into ELabBook.

The specific models used have changed appreciably with successive implementations of CLP. For example, the earliest mental model was part kinetic theory and part calibration and measurement, where the idea was to "integrate information about the role of variables and the modes of measuring changes in temperature and heat energy" (Linn & Songer, 1991, p.894). The

apparent lack of success in seeing students integrate or subsume this into their natural knowledge led to a change in the model from kinetic theory to a macroscopic mode of heat flow resembling the old idea of the *caloric* but with no mass. This was considered appropriate based upon the finding that most scientists have this same macroscopic model of heat flow in mind when they conceptualize or make predictions based on their own natural world observations (Lewis, 1991). The heat flow model and the kinetic theory model predict similar outcomes in a wide range of circumstances, so that the vast majority of intuitive conceptions formed under one model will not be challenged with adoption of the other. The use of the heat flow model may be considered a bridging analogy to facilitate conceptual change (National Research Council, 2007).

During CLP curriculum development, it was noted that students remained unable (in the main) to distinguish between heat energy and temperature, even while making use of the "simpler" heat flow model. At this point, making certain learning strategies such as predictions and observations an explicit, assessable part of the curriculum stimulated increases in cognitive demands – note that they are a form of scientific articulation and reflection. These increases were balanced by decreases in cognitive demands made by reducing the breadth of concepts introduced, notably calibration and measurement. Linn & Songer (1991) state that the students were able to use the feedback from the observations and the self-monitoring from reexamination of the predictions to better their understanding, the type of feedback loop one would expect from the second and third science learning strands of generating scientific evidence and reflecting on scientific knowledge.

At this point, one begins to see the complementary nature of PBS and CLP, and why utilizing both in the thermodynamics unit constructed for this study fits the key parameters for success in scaffolding knowledge growth, and engaging the students' metacognitive processes that have been discussed in this chapter. The use of computer technology is considered fundamental to both. Both are based on the assumption of a constructivist approach to learning. Both attempt to address the idea of knowledge integration between "in-school" and "out-of-school" knowledge; PBS takes a more tacit approach where CLP is discrete. Both value investigation, reflection, evidence gathering, and peer collaboration, which relates directly to the science learning strands. With respect to conceptual change, CLP could not be classified as completely "bottom-up" in its approach because of its explicit dependence upon these principles, neither is it "top-down"; perhaps it can be considered "low side-in", with an entry point closer to the bottom than the top. PBS does not require any one approach, although "top-down" or "low side-in" is implicit within its design. They differ in that with CLP, a pragmatic model of heat flow is presented explicitly (or at least hinted at strongly) while the PBS approach might call for such a model to be discerned within the course of learning. This pragmatic model, which may be considered a collection of overarching principles, serves as a type of social discourse whose merit is supported inductively, by experimentation; the principles are not left to stand as unassailable pillars of the absolute.

The choice to make use of MBL in the curriculum satisfies the notion of CLP being "amenable to available technology." The computer was chosen as a type of "silent lab partner", which "facilitates experimentation, helps the students build robust representations of the phenomena under investigation, and supports effective hands-on learning" (Linn & Songer,

1991, p. 890) These advantages of having a computer as a lab partner are reminiscent of those of a cognitive partnership between student and computer elaborated upon by Salomon, Perkins & Globerson (1991).

The CLP makes use of MBL but with a different software design than that of the first generation. ELabBook is a software suite, written for the Macintosh as a series of HyperCard stacks (Linn & Hsi, 2000). With ELabBook, a group of 1-3 students are first given the opportunity to describe the purpose of an experiment or simulation, and then to make some design choices about that experiment or simulation. They must then create textual and graphical abstractions that serve as predictions of the phenomena that they expect to witness; individuals within an experimental group may even register dissenting opinions that they have with respect to the group's predictions. The group then proceeds to setting the graph's axes and select or perform a calibration. Once the group has constructed the physical experimental apparatus, they proceed with the experiment, observing the phenomenon as it unfolds. When the data collection interval has expired, the group is then asked to perform several types of post-hoc analysis, which may include an interpretation of the graph, accessing the data from other groups, synthesizing a general principle from the results, and summarizing the investigation. A simulation may be chosen instead of an experiment, where the only difference is that no calibration or apparatus are needed.

It was previously mentioned that having students write down their predictions and observations of scientific phenomena helped improve their knowledge integration (Linn & Songer, 1991). With ELabBook, the idea is to then explicitly scaffold the learning process by

building predictions, observations, and other types of analysis and reflection into the software. This was embedded to promote knowledge integration about thermodynamics; Lewis, Stern & Linn (1993) state that the design purpose of ELabBook is "to encourage students to do the extra processing to link pieces of information" (p. 48), with the simultaneous goal of ease of use. This is a direct embodiment of knowledge integration, and is an improvement on the aforementioned facility of MBL to scaffold sense-making.

An additional feature related to supporting the learning process provided in ELabBook was for the teacher to define the problem space. This was a quantum increase in the development of computer-mediated scaffolding, as it allowed one to quantitatively examine the well known knowledge types proposed by Shulman (1986): subject matter, pedagogical content, and curricular. Through this *teacher interface*, the teacher is able to determine the types of investigations (whether simulations or experiments), the broad categories into which they may be fitted, and the protocol that the students are to follow. Certain tasks, such as the statement of purpose, parameter selection, predictions, post hoc analyses, and summary can be made mandatory or optional, and the sequence can be prescribed or left flexible. Further, the teacher can determine which overarching principles govern the experiments, and can write the prompts that elicit student reflection regarding each of these tasks. Thus, in a series of experiments the problem space can proceed from prescribed to open-ended.

What is apparently missing in the CLP literature is an explicit rationale for designing these scaffolds into the software. A technology skeptic (Clark, 1994) would question why it is better for the students to make their predictions and observations on the computer rather than

with paper and pencil. One possible reason for including the scaffolds in the software is guidance or control: the teacher is able to either guide or control (depending on one's perspective) the students' experimentation. Zhang and Quintana (2012) elaborate on a positive rationale for such technology-based scaffolding with several ideas: creating an interated working space that holds all of the students' thoughts and work in one space and reducing the amount of working memory needed to manage and recall that thinking, and making an implicit activity structure explicit so that steps that are important to good inquiry are not overlooked because of naivete or even laziness. There is a risk to decreasing student motivation at both ends of this problem space; too much prescription can force the student into regimentation that is not seen as authentic which could be accompanied by a "rebellion" of not completing or fully engaging with required steps (Roscoe, Segedy, Sulcer, Jeong and Biswas, 2012), while too much openness can frustrate the student who does not have enough content knowledge to feel like they can make knowledgeable choices (Kim & Hannafin, 2011). The presence of these scaffolds in the software raises some interesting questions about second generation MBL: what motivational advantages and disadvantages are incurred by their presence? How might these promote and impede the learning of science?

The ability of students to communicate and share data from their own to other networked computer stations was also implemented. This capacity takes the form of a message window for remarks to be sent along with an option to pass along a screen shot of the card showing the graphs, so that students can share evidence along with commentary. In addition, two types of post hoc analysis known as "research from other groups" notes and "exchanging research" worksheets were implemented to help guide collaboration with other groups. In contrast to first

generation MBL, scaffolding of articulation and reflection per Quintana, et al (2004) in ELabBook is a first-order characteristic.

A direct discussion of motivation is noticeably absent in the outstanding array of reports that have arisen from the CLP program which define its goals and stages of development. CLP (and ELabBook) was derived exclusively from a consideration of what cognitive demands are appropriate for middle school students. Stern (1994) confirms the fact that motivation is not specifically addressed in any of the classroom research associated with the development of ELabBook. However a closer reading reveals that the developers of CLP do address motivational issues and concerns in their literature. They do not couch them in terms of familiar constructs because rather than CLP research crossing the boundary between cognition and motivation, the boundary crossed CLP research by way of the changes to conceptual change instigated by Pintrich, Marx & Boyle (1993) and subsequent interest in metacognition. For example, Lewis, Stern & Linn (1993) review student comments about ELabBook that center on the issue of "choices"; either students appreciated the fact that they could make choices or they wished that this capability were strengthened. The term "choices" appears to be directed toward parameter selection and experimental design, but also touches on the motivational construct of locus of control. As a second example, in discussing the domain of thermodynamics, Linn & Songer (1991) articulate points that emphasize the need for engagement with the students' "out-of-school" experiences or natural knowledge, which has been previously addressed from a motivational perspective as authenticity. However, they are not alone in overlooking the role of motivational constructs in MBL. Berger, Lu, Belzer and Voss (1994), in their review of research on technology in science education, report no instances where MBL studies have looked at



motivation. Nakhleh (1994), in her review of the effect of MBL on science learning, likewise reports no such studies; in her concluding remarks she calls for

"studies which provide descriptions of how MBL interacts with students' attitudes towards science and technology and how the freedom and flexibility of MBL affect students' motivation . . ." (p. 378).

Later studies or descriptions of the effectiveness of MBL that touch on the motivation of the learners may mention words such as "interest," "motivated," "excited," etc., or address conceptual change, metacognition, or scaffolding, but don't examine motivation by way of specific constructs or mechanisms described previously. Casey (2001), Wetzel (2001), Marcum-Dietrich and Ford (2002), Metcalf and Tinker (2003), Millar (2005), Niess (2005), Vonderwell, Sparrow and Zachariah (2005), and Karoulis (2006) exemplify this type of study or publication. Blumenfeld, Kempler & Krajcik (2006) echo Nakhleh's advice a decade later in calling for more explicit research on how to promote student motivation. This study will address these open questions about motivation by defining specific constructs – the five feelings defined earlier in the chapter - and assessing how they changed across the project and how they correlated with knowledge growth and science understanding, for the purpose of highlighting them for inclusion in other variants of educational technology.

By this time, the CLP project has reached final maturity, and the ELabBook software no longer runs on modern computers and is essentially defunct, but nevertheless the program and the software leave a distinctive legacy in the use of technology for science teaching and learning with its capability to run simulations. Collis and Stanchev (1996) foresaw an evolution of MBL into Multimedia Labs (MML), where one piece of software allows visualization of science phenomena, simulation of experiments, and data acquisition and analysis of real-time

experiments. While both multimedia visualization and MBL software have each grown in sophistication and use, ElabBook remains a high-water mark for a computer based learning environment that can be used for both simulations and real-time data acquisition and analysis, with embedded scaffolds. Tinker (2001) traces an inevitable evolution of computer software and hardware that places all technological tools into currents of history that are here today and gone tomorrow. This means that lessons learned from employing one device or tool should be extended as widely as possible.

### **Summary**

In this chapter, a connection with the research literature was established in order to provide a theoretical basis for the research study. The fundamental research question under investigation involves a look at how technology affects science understanding and motivation towards science learning, especially within a context of an at-risk student population. The basic principles and research from the learning sciences on how students learn science were explored, with special emphasis on conceptual change, with explanations of the key learning strands endemic to science learning, and with focus on specific motivational constructs which can also be applied to the study of the at-risk learner. Since the learning environment for this study is built upon on a combination of project-based learning, the Computer as Lab Partner project, and microcomputer-based laboratory, a description of each of these principles and how they support student learning was provided. The basic model for increasing science understanding that was proposed in chapter one was expanded to include variables of interest related to each component, variables that can then be quantified, instantiated, measured, and analyzed.

A description of the classroom and school, the curricular design for the unit, and an educational timeline and narrative of the project is provided in the next chapter.

### CHAPTER 3

#### THE PROJECT

This chapter contains a description of the thermodynamics project implemented within this study, from the classroom perspective. Cuban (1992), in his analysis of the history of curriculum, distinguishes between different phases that a particular curriculum passes as it proceeds from conception to execution to remembrance. The *intended* curriculum is that which has been conceived in forethought, often from simultaneous theories of pedagogy, learning, and knowledge. The *taught* or enacted curriculum is that which is actively presented to the students in the classroom, and thus subject to constraints of resource, atmosphere, and human interpretation and judgement. The *learned* curriculum is that which the students have internalized. Cuban's terminology and definitions, as applied to the history of this thermodynamics project, are the basis for organizing the story described in this chapter.

The students and teacher who were involved in this study were experiencing a curriculum based on project-based science for the first time. Marx, Blumenfeld, Krajcik & Soloway (1997) describe one important challenge regarding first-time enactment of project-based science, a challenge that impinges upon both students and teacher: the departure from the norm of "in-school" learning. For a student, it means that past learning strategies, memorization skills, and the habit of individual work gives way to learning strategies that support greater thoughtfulness and collaborative work. For teachers, it means that traditional teaching approaches, management

practices, assessments, and use of technology and other media require extensive retooling. Thus, observations of how the students and teacher (and researcher!) met this challenge will be included later in this chapter's discussion of the learned curriculum.

The thermodynamics curriculum used in this study is linked to Michigan's state science standards. The specific linkage is shown in the project plan discussed later in this chapter, and the details are provided in the appendix. The importance of linking the curriculum to state or national science standards in order to provide cohesion between the science concepts being learning has been highlighted by numerous researchers, including Duschl (2007), National Research Council (2007), Krajcik, McNeil & Reiser (2008), Roseman, Stern & Koppal (2010), and National Education Technology Plan (2010). The State K-12 science standards extant at the time this study was performed were known as the MEGOSE, or Michigan Essential Goals and Objectives for Science Education (Michigan Department of Education, 1991). The MEGOSE may be understood as the State of Michigan's response to the report known as *Science for All Americans* (AAAS, 1989), which attempts to synthesize contemporary science knowledge and practices with science education with a goal of promoting science literacy for all K-12 students - and thus by extension for all Americans. The AAAS report formed the basis for succeeding national science education benchmarks (AAAS 1993; 2001; National Research Council 1999; 2003; 2007). MEGOSE similarly influenced successive State benchmarks known as the Michigan Curriculum Framework (Michigan Department of Education, 1996; 2000), the Grade Level Content Expectations for K-8 (Michigan Department of Education, 2009), and the High School Content Expectations for 9-12 (Michigan Department of Education, 2006).

As noted in chapters one and two, this particular school was considered to have a significant number of its students as educationally at-risk. Songer, Lee and Kam (2002) talk about a bias for the curriculum and teaching in such instances to sometimes follow what Haberman (1991) calls a “pedagogy of poverty” that is highly directive and teacher controlled and contrary to constructivist and inquiry practices. They also suggest that “staying the course” with good inquiry practices and standards-based teaching better supports student learning. The latter approach was the philosophy used in this study.

### **An Overview of the Teaching of Thermodynamics**

Linn & Songer (1991) note that thermodynamics is a fundamental concept in physical science and a domain, which shapes the understanding of many scientific phenomena that helps form the world of a middle school student. The effects of thermodynamic change can be readily seen in a wide variety of applications. For these reasons, thermodynamics was chosen as the domain of interest for the Computer as Lab Partner (CLP) curriculum. Since the subject of heat transfer is appropriate within MEGOSE for middle school students, which some extensions backward to elementary students and forward to high school, the CLP was used a curricular foundation for this study. Linn and Songer propose that the cognitive goal of CLP is to "encourage students to construct an integrated view of thermodynamics based on the mental model or models provided" (p. 889). Linn & Hsi (2000) identify the key thermodynamics topics of the CLP curriculum as understanding the difference between heat and temperature, the

concept of thermal equilibrium, and the commonality and uniqueness of thermal insulation and conduction.

Within project-based science (PBS), a central tenet of designing a project is to construct a driving question that is both authentic and interesting to the student (Blumenfeld, et al, 1991). This driving question also serves as an anchor for conceptual organization of various concepts and sub-questions. The driving question frames the circumstance of which one may be asked to make sense; it addresses a real world problem to be constructed, explored, and answered, one that the students find meaningful which requires knowledge from the subsequent curriculum that can be reasonably imparted. Once that question has been determined, several sub-questions should emerge, where each sub-question is aligned with science content related to state or national standards. At this point, a process of iteration may be necessary between driving question, sub-questions, and content until satisfaction with each is attained. When that happens, the foundation for the project is built.

For this project, the concept behind the driving question was proposed by the researcher, and then discussed and fleshed out by both the teacher and researcher; the result was very much based on a joint effort. The wording of the driving question was crafted by the teacher, based on his understanding of what was within the intellectual grasp and appeal of the students, and took the form of both a question and a scenario. The question was "How do you keep hot things hot and cold things cold." The scenario took the students to an engineering research and development facility, where as research teams they would work to develop an insulating device that would mitigate the temperature change of a fluid which is placed in a thermodynamically

hostile environment. In order to investigate this question, students clearly need to have a working understanding of which materials and design characteristics are important, e.g. sealing of any penetrations. In order to develop that understanding, they would need to discover what heat is (the first law of thermodynamics), how it is measured (calibration and measurement), and how it behaves (the second law of thermodynamics).

### *Core Concepts of Thermodynamics*

The laws of thermodynamics are essentially judgments regarding the nature, behavior, and measurement of heat energy; however, they can be difficult to discern and generalize, and are often flavored differently by scientists from diverse domains. An understanding of the first law goes hand-in-hand with the concept of heat as thermal energy, and helps the student differentiate between heat and temperature. The first law is part and parcel of the CLP curriculum, and in fact has risen to even greater importance as CLP has recently been reformulated again to emphasize forms of energy of which heat is but one (Stern, 1994). Wark (1977), from the perspective of an engineer, describes a first law of thermodynamics where, in the case of energy transfer from one form to another within a given system, the total quantity of energy involved in the transfer is constant. Bailar, Moeller, Kleinberg, Guss, Castellion, and Metz (1978), from the perspective of chemistry, relate the first law to the idea that the energy of the universe is constant. Halliday and Resnick (1978), from the perspective of physicists, also point to a process of transformation of energy from one form to another, the total being conserved. They also note that historical scientists such as Carnot, Mayer, Joule, Helmholtz, and Colding all established the principle of energy conservation in the mid-19th century (relatively



recently), that this seemingly self-evident principle was not sensed by Galileo or Newton, and that it was initially met with skepticism and denial.

The differences in statements of the second law are even starker. An understanding of the second law serves as an important foundation for future science investigation of heat capacity and specific heat, Carnot cycle, thermal efficiency of engines, and thermal conductivity and diffusivity. The second law is the main focus of the "classic" CLP curriculum, serving as the basis for understanding why heat flows and how that flow differs within different materials, differently-sized and shaped volumes, etc. Wark (1977) describes the second law of thermodynamics where the quality of energy (also thought of as the "suitability" of the energy as a source for work) degrades with use. Bailar, etc. (1978) relates the ideas that all systems naturally move toward equilibrium or that the entropy of the universe always increases. Halliday & Resnick (1978) emphasize the fact that the first law alone does not obstruct a cold object from coming in contact with a warm one, surrendering its heat to the warm one, and becoming colder; thus, there is a need for a second law which states that this does not naturally occur.

Initially, calibration and measurement were included in the CLP curriculum, again to serve to help students differentiate between heat and temperature. In the puberty of CLP curriculum development, it was observed that students remained unable (in the main) to distinguish between heat energy and temperature, even while making use of the "simpler" heat flow model. To help scaffold deeper understanding, making student thinking visible using certain learning strategies such as predictions and observations stimulated increases in cognitive demands. The predictions and observations were made an explicit aspect of ELabBook so that

they could be assessed by both peers and the teacher (Linn & Hsi, 2000). However it was judged that a decrease in cognitive demands, corresponding to the increase introduced along with prediction and observation, was necessary. Thus, the focus upon calibration and measurement was dropped. In doing so, a positive and defining characteristic of a "bottom-up" approach was eliminated. In such a situation, one often ends up attempting to understand the theory alone rather than also understand the data, such that calibration and measurement become afterthoughts or are ignored – bypassing an important aspect of the second science learning strand discussed in the previous chapter, generating scientific evidence (Michaels, Shouse, and Schweingbruber, 2008). Therefore calibration and measurement were included in the curriculum for this study.

Caws (1965), in discussing the philosophy of science, states that "we do not say we are measuring unless we know what we are doing - that is, unless we know *both* how to get the numbers *and* what the numbers stand for" (p. 156). He goes on to say that measurement does not mean simply allowing numbers to bridge phenomena with theory, but rather allowing numbers to bridge a perceived theory or hypothesis with an arithmetic model. Furthermore, calibration lends itself to the actual understanding of how those numbers are generated, and how well they are to be trusted. Pushkin (1996) suggests some of this omission in his criticism regarding the lack of attention and differentiation made between thermal conductivity and specific heat. The thickness of insulating materials is not addressed in ELabBook simulations or examples, and a prime example of this is seen in a comparison of the graphics and thermal diffusivities provided for aluminum wrap and for "no wrap."

In the case of the potato simulation, the "no wrap" drawing that the students see is of a potato, with skin. In the case of the coke simulation, the drawing that the students see is of an aluminum can of coke; note that the can itself acts as a "wrap" for the liquid coke. If one were to perform a coke simulation and choose to compare "no wrap" and aluminum wrap, one would find that the warming curves were identical. This occurs because in ELabBook, the thermal diffusivities used for "no wrap" and "aluminum wrap" are defined to be the same. In terms of the materials used, this is reasonable; however, in terms of material thickness, the portrayal is inaccurate, especially for larger thicknesses of aluminum wrap. In the case of the potato simulation, the fact that the two are the same is unrealistic, because a bare potato is in no way impinged upon by aluminum.

This lack of attention to "how to get the numbers" and "what they stand for" was addressed in this study by including an entire section in the project on how heat is measured. In this way, it is hoped that students would understand in a tangible way that temperature is a type of measurement - a number - used to help assess the affect of the phenomenon - thermal energy.

### *Scaffolding Learning*

Because CLP and PBS share a constructivist perspective, much of the philosophy and specific techniques for scaffolding learning devised for CLP is useful for this PBS-based study as well. The most remarkable example is the adoption of a macroscopic heat flow model for this project. Lewis (1991) describes how this model was conceived and utilized within the CLP. The model of heat resembles the historical concept of the *caloric* except that mass is neglected; thus, heat is considered to be a type of energy that flows from place to place in the presence of a

temperature gradient. The choice was based on a pilot study which indicated that most scientists have this same model in mind when they conceptualize or make predictions. She notes that people who utilize kinetic theory (which is most widely used to explain the process of heat transfer) and the heat flow model will predict similar outcomes under a wide range of circumstances. The CLP developers conclude that the vast majority of intuitive conceptions formed under heat flow will not be challenged with subsequent adoption of kinetic theory. Some question has been raised regarding the scientific accuracy of the heat flow model, particularly the use of the term "heat energy," but the challenge appears to have been answered (Pushkin, 1996; Lewis & Linn, 1996). Students are scaffolded in seeing how their simulations align with this model through a section in the interface known as the principle, where students explain how what they observed in terms of macroscopic heat flow. Other examples of insightful scaffolding include the use of predictions and observations as assessable aspects of ELabBook and the use of real-world objects and situations in all assessments.

A concept map (Novak & Gowin, 1984) of the unit is an important tool for managing the project. A particular concept-mapping tool called the Project Integration and Visualization Tool or PIViT (Marx, Blumenfeld, Krajcik and Soloway, 1998) was used in this study. PIViT allows a project map to be developed which represents the complexity of a unit plan according to components such as driving questions, conceptual knowledge, classroom activities, classroom investigations, connections to standards, and artifacts of learning. The unit can be represented graphically, textually, and chronologically (calendar form). It also allows for the complexity of the project to be managed, as pieces of the project can be assembled and operated on either integrally or differentially. Details about each of the above components are linked to each

component for easy access, such as an overview of an activity or investigation, learning objectives and targeted conceptual or process knowledge, materials and procedures used, assessment of learning, and alignment to standards. For this study, the driving question and scenario, the assessments, the investigations, the discussions, the science concepts, and the relevant state science benchmarks were assembled and interlinked. Figure 3 shows a map of the thermodynamics project, which was initially created with PIViT but is recreated here with another concept-mapping software, Inspiration®. The complete map in Figure 3 is a bit difficult to interpret as it is quite busy because it shows the complexity of all the interrelationships between the various pieces of the curriculum. The directional arrows convey a link between any two concepts, with the idea that the more links that enter or exit a node, the more efficient a role that designed aspect of the curriculum plays in helping students answer the driving question.

Figure 3 also shows a key for each of the geometric shapes or nodes that correspond to the aspects of PBS described in chapter two. The driving question and other sub-questions are represented by beveled rectangles. Science concepts are represented by ellipses. Trapezoids indicate external curricular goals or objectives, such as those mandated or suggested by the district, county, or state. Parallelograms indicate classroom discussions and/or other "teacher-centric" activities, activities which can take place inside or outside the classroom. Sharp rectangles stand for student investigations, which are either open-ended or which can follow a variety of paths toward a particular learning outcome. Hexagons stand for artifacts created, assessments made, and other tangible expressions of student understanding (in the actual PIViT map, these shapes are octahedrons).

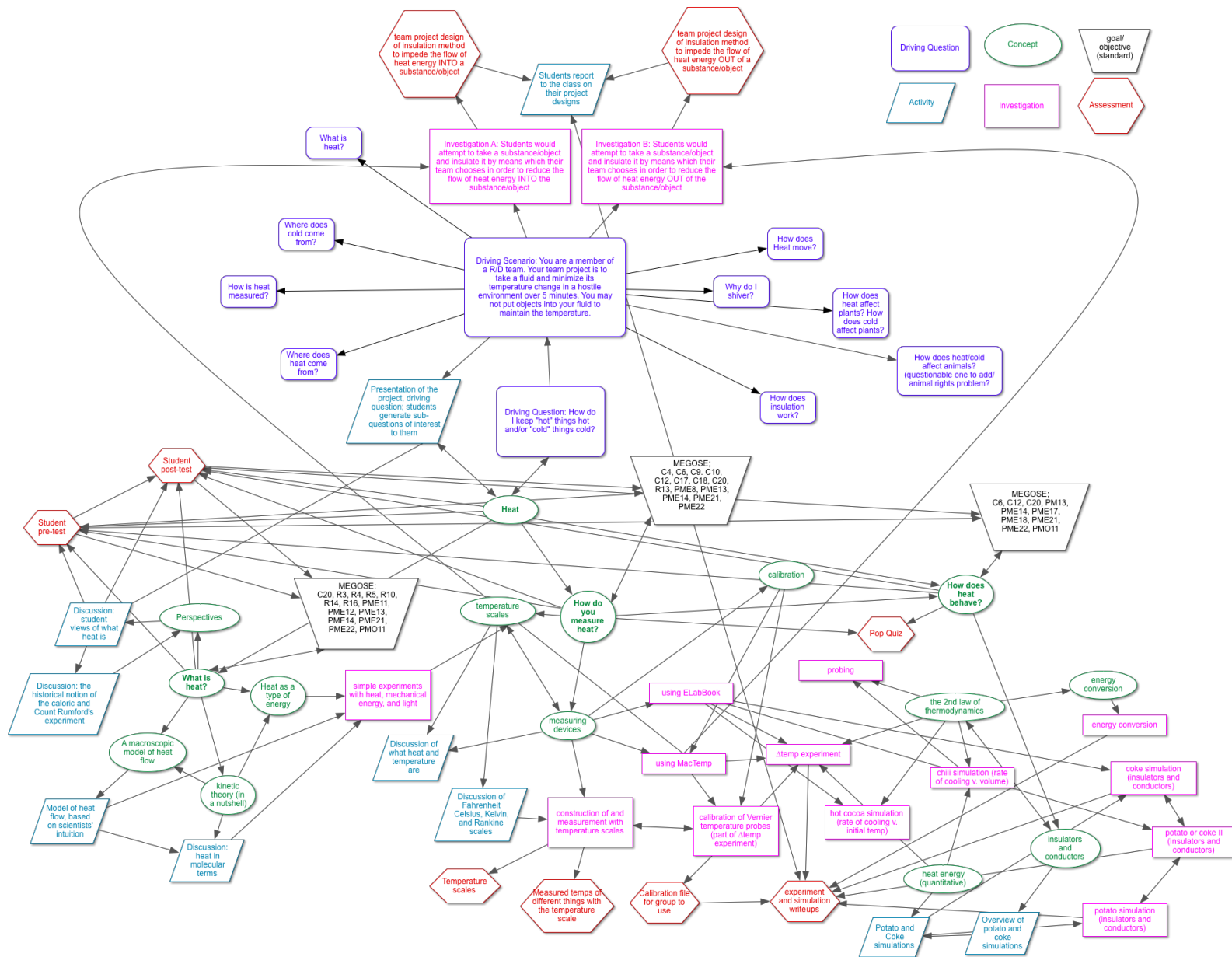


Figure 3: Project-based instruction plan for the thermodynamics project

Greater detail of this map will be shown later throughout the chapter, to allow easier reading and interpretation of the various pieces of the curriculum. Additional detail is embedded in the map via a textual description or a type of lesson plan unique to each geometric shape that may be read or edited by “double-clicking” on the shape.

### *The Driving Question*

The driving question for the project was conceived as both a question and a scenario. While there are numerous everyday applications involving a proper grasp of the laws of thermodynamics the challenge was in choosing an application that would present appropriate challenge and interest for eighth grade students’ learning. Approximately seven weeks of instructional time were allocated to carry out this project. It was also firmly value that the students would have to design, build, and test an artifact of some type using everyday materials.

Caws (1965) summarizes the objectives of scientific investigation as description, understanding, and control. Applications involving the second law of thermodynamics present involve an attempt by man to "wrestle" for control of his environment, in that people are constantly trying to maintain objects or environments at a given temperature in spite of the surroundings. Harkening to the macroscopic model of heat flow, a scenario where students sought to discourage heat flow appeared appropriate. Thus, the driving question of *How do I keep "hot" things hot and "cold" things cold?* was birthed. However, some concern remained about whether the topic would still be motivationally "dry."

The solution was to subsume this question beneath a complementary driving scenario, an approach that stays within the boundaries of PBS orthodoxy even as it strains it somewhat. In a previous experience with an educational multimedia system, a scenario where small groups of students waged a friendly competition that resulted in a prize for the most successful class appeared to be motivationally successful. Thus, it was determined that student groups of 2-3 members would again wage a friendly competition, this time to construct a passive thermal insulating device. The competition would come in the quest to make the device work as well as possible - to minimize a temperature drop in a hostile environment over a fixed time period. This could be thought of as an anchored experience, a shared experience among students related to learning science content that is a feature of project-based science. The authentic nature of this scenario involved the fact that the students would be attempting to solve the same problem as engineers at multimillion-dollar companies like Thermos™, Igloo™, or Coleman™.

The content focus for this unit of study is "Heat." The definition of the first and second laws of thermodynamics that bound the concept of "heat" are taken to be as follows:

"Energy is neither created or destroyed in the conversion of heat to or from other forms of energy" (first law) and "A transfer of energy from one body to another proceeds naturally and continuously from the warmer to the cooler body"  
(Standard Educational Corporation, 1983, p.H-111)

The section of the project map shown in Figure 3 that pertains to the driving question and scenario is shown in closeup as Figure 4. The scenario is not really part of project-based science but was an enhancement to the plan suggested by the teacher.



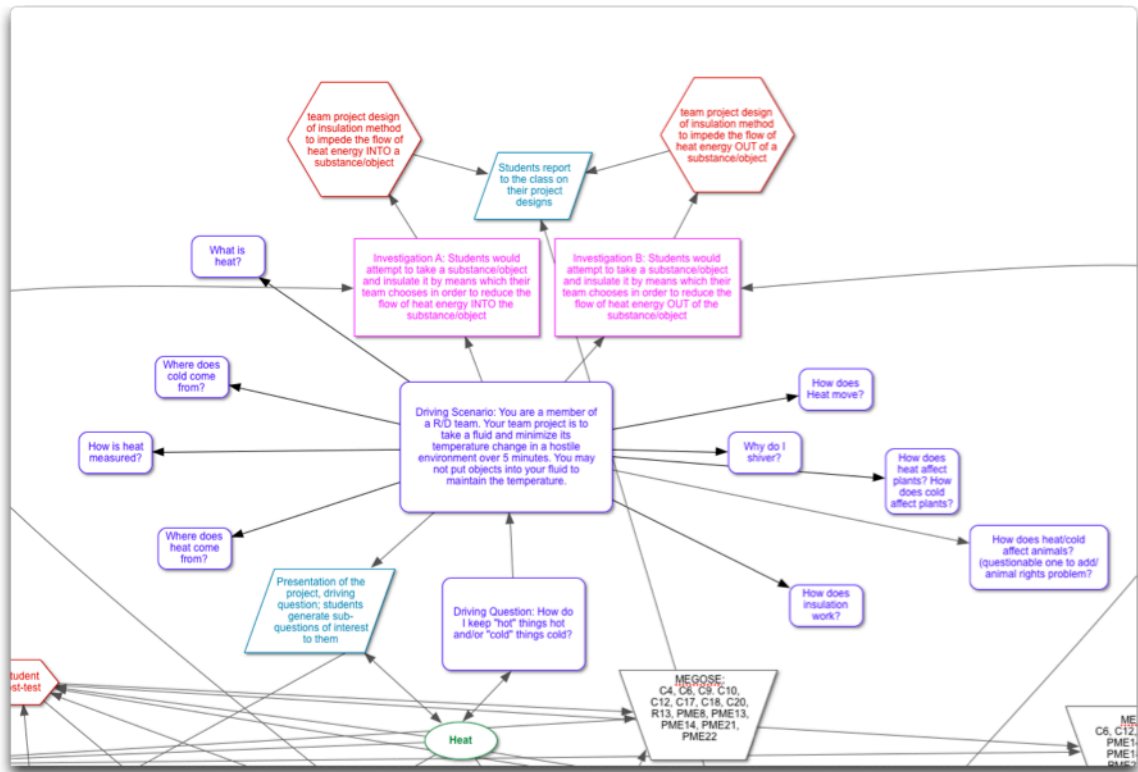


Figure 4: Expanded view of driving question and scenario

The science content for the project is structured around three sub-questions determined by the teacher and researcher: "what is heat?" "how do you measure heat?" and "how does heat behave?" Assorted driving sub-questions are anticipated to reflect the predicted interests of the students, but are not presumed to be a closed set. These driving sub-questions include "What is heat?" "Where does cold come from?" "How is heat measured?" "Where does heat come from?" "Why do I shiver?" "How does insulation work?" "How does heat move?" and "How does heat or cold affect plants and animals?"

The CLP curriculum, the University of Maryland Probreware Project (Layman & Krajcik, 1988), and the MEGOSE (Michigan Department of Education, 1991) serve as curricular models for the cognitive demands that could be made upon the students.

## What is heat?

The first sub-question to be addressed would be "What is heat?" This section involves a relatively large amount of discussion because of the need for the students to understand certain background information. The section of the project map shown in Figure 3 that pertains to "what is heat?" is expanded in Figure 5.

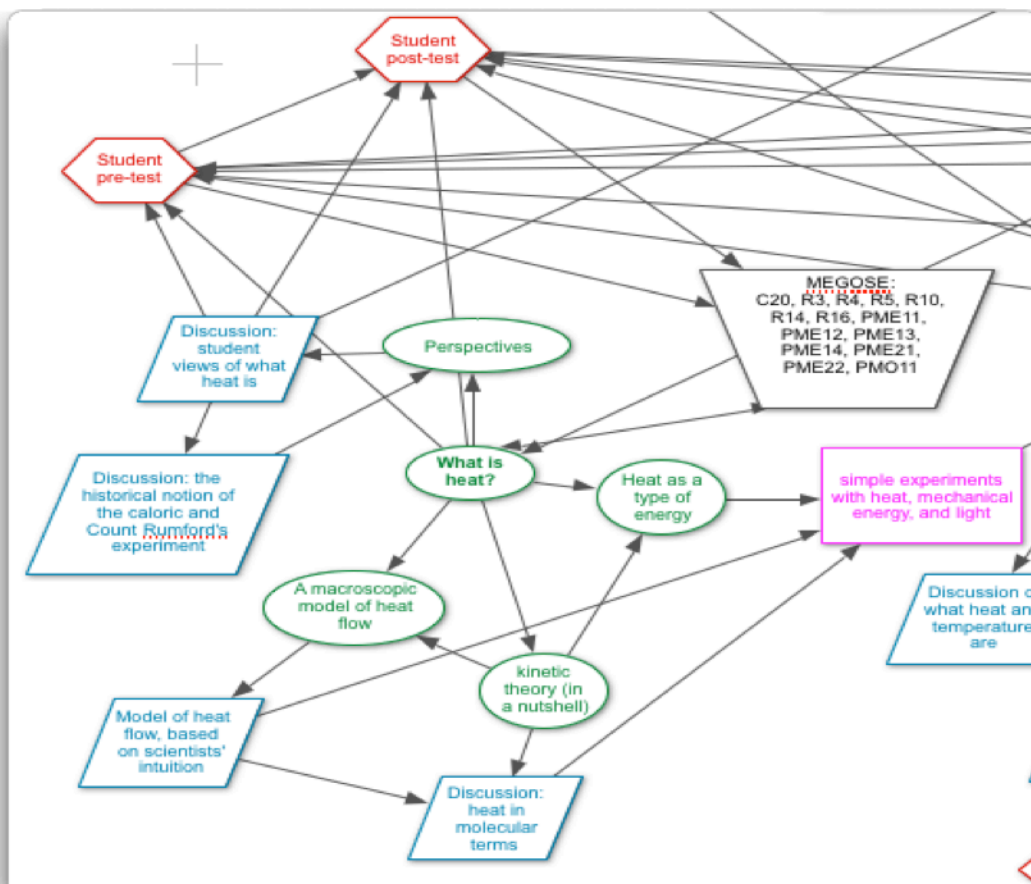


Figure 5: Expanded view of "What is heat?"

### *Intended Curriculum*

The four principal content areas to be explored are Perspectives, Heat as a type of energy, Kinetic theory, and a macroscopic model of heat flow. *Perspectives* is intended as a starting point for the project, to determine the students' existing conceptions of heat, temperature, and thermodynamics. It involved data from interviews with 31 of the students and a pretest of all four classes. The interview and pretest were part of the data gathering process for this study, and are described more fully in chapters four and five. *Perspectives* also includes a classroom discussion where additional driving sub-questions are elicited. It also includes a classroom discussion of the historical notion of the caloric and Count Rumford's observations of how blunt drilling bits appeared to cause a substantial amount of heat generation. This sets the stage for *Heat as a form of energy*. For this concept, different students from each class perform a series of experiments of small duration which exhibit the transfer of energy from a particular form to that of heat. As a whole class, the students' observations are discussed, with special attention given to changes in heat energy. These experiments reinforce the concept behind the first law of thermodynamics before the law is rigorously stated, so that the students formulate their conceptions about energy conservation from observation and experiment rather than theory.

The next concept, *Kinetic theory*, is presented without any predictive power. It is presented because it does represent scientists' current understanding of how heat energy is defined and how it changes. However, no experiments or other means by which students would draw on their knowledge of kinetic theory to predict or control an experiment were made. Because of this, the discussion around this topic is the "driest" of all in the project. The decision

to proceed in this manner was made on the basis of the CLP developers' suggestion that such an approach would be too cognitively demanding for eighth grade students. While some mention of kinetic theory was desired, the predictive basis for all observation and experimentation would stem from the *macroscopic model of heat flow*. Students are presented with formal definitions of the first and second laws of thermodynamics, and reminded that these laws are heuristics based on observations akin to those that they have already made, so that key concepts are shown to be plainly intuitive and understandable. Here, the students find that many scientists personally utilize the heat flow model and that for their purposes the predictive power of this model is satisfactory. Each of the energy conservation experiments that they analyzed together earlier are reexamined within a context of heat flow.

A posttest and interview, given at the end of the project, helped determine changes in the students' perceptions from the beginning. As before, these aspects of construction, validity, reliability, and data gathering are further elaborated in chapters four and five.

### *Enacted Curriculum*

In general, these students showed many of the classic alternative conceptions of thermodynamic phenomena (Lewis, 1991). Some of the more popular beliefs included:

- That a given material may function well for keeping something cold and poorly for keeping something warm, or vice-versa;
- That "heat", "heat energy", and "temperature" may be used interchangeably; a lack of distinction between "heat" and "warm air" was noted as well;
- That aluminum foil was an all-purpose choice for keeping substances cold or warm;

- That it was possible for materials which are initially "hotter" or "colder" than the mean temperature of a closed environment to continue to be hotter or colder than the mean even after long time periods; and
- That large masses and small masses of the same material have the same amount of heat energy if their temperatures are equal.

There were also some scientifically accurate conceptions that many of these students already understood, namely that dark colored objects absorb more heat from impinging light energy than light colored objects, and that larger volume and smaller surface area mitigated the cooling rate of objects at the same temperature better than smaller volume and larger surface area.

The project plan portrayed in Figure 3 was implemented with very little content change. One driving sub-question generated by the students that led to considerable discussion early on was that of how one could burn themselves from contact with cold substances such as dry ice. This discussion served a useful purpose in helping take the emphasis for thermodynamics off of fixed temperature states ("you can get burned by things that are hot") and putting it in terms of heat transfer rates ("you can get burned when a lot of heat is transferred through a small area of skin").

An important factor that required curricular adjustment was the lack of contiguous classroom time, especially in this segment of the project. Snow days, half-days, special school programs, assemblies, and various forms of institutional absenteeism seemed to figure in disproportionately during this period of the project. Figure 6 shows a graphic from the calendar feature of PIViT with the scheduling of the activities, investigations, etc. portrayed in Figure 3.

<b>Feb 20, 1995</b>	<b>Feb 21, 1995</b>	<b>Feb 22, 1995</b>	<b>Feb 23, 1995</b>	<b>Feb 24, 1995</b>
		Presentation of the project, driving 	Student pre-test 	Discussion the historical notion of the 
		Discussion: student views of what heat is 		Discussion: heat in molecular terms 
<b>Feb 27, 1995</b>	<b>Feb 28, 1995</b>	<b>Mar 1, 1995</b>	<b>Mar 2, 1995</b>	<b>Mar 3, 1995</b>
<b>Mar 6, 1995</b>	<b>Mar 7, 1995</b>	<b>Mar 8, 1995</b>	<b>Mar 9, 1995</b>	<b>Mar 10, 1995</b>
Discussion: heat in molecular terms 	simple experiments with heat, mechanical 	Model of heat flow, based on scientists' 	Discussion of Fahrenheit, Celsius, 	Construction of and measurement with 
		Discussion of what heat and temperature are 	Construction of and measurement with 	Temperature scales 
				Measured temps of different things w/ the 
<b>Mar 13, 1995</b>	<b>Mar 14, 1995</b>	<b>Mar 15, 1995</b>	<b>Mar 16, 1995</b>	<b>Mar 17, 1995</b>
Using ELabBook 	Using ELabBook 	Using ELabBook 	potato simulation (insulators and) 	potato simulation (insulators and) 
		potato simulation (insulators and) 		coke simulation (insulators and) 
<b>Mar 20, 1995</b>	<b>Mar 21, 1995</b>	<b>Mar 22, 1995</b>	<b>Mar 23, 1995</b>	<b>Mar 24, 1995</b>
potato simulation (insulators and) 	coke simulation (insulators and) 	coke simulation (insulators and) 	coke simulation (insulators and) 	potato or coke II (insulators and) 
coke simulation (insulators and) 	potato or coke II (insulators and) 	potato or coke II (insulators and) 	potato or coke II (insulators and) 	chili simulation (rate of cooling v. volume) 
		chili simulation (rate of cooling v. volume) 	chili simulation (rate of cooling v. volume) 	hot cocoa simulation (rate of cooling v. initial) 
<b>Mar 27, 1995</b>	<b>Mar 28, 1995</b>	<b>Mar 29, 1995</b>	<b>Mar 30, 1995</b>	<b>Mar 31, 1995</b>
Overview of potato and coke esimulations 	Potato and Coke Experiments 	Using MacTemp 	Temperature $\Delta$ experiment 	Temperature $\Delta$ experiment 
experiment & simulation 		Calibration file for group to use 		
<b>Apr 3, 1995</b>	<b>Apr 4, 1995</b>	<b>Apr 5, 1995</b>	<b>Apr 6, 1995</b>	<b>Apr 7, 1995</b>
Temperature $\Delta$ experiment 	Temperature $\Delta$ experiment 	Pop Quiz 	Investigation B : Sudents would attempt 	Investigation B : Sudents would attempt 
	experiment & simulation 	Investigation B : Sudents would attempt 		
<b>Apr 10, 1995</b>	<b>Apr 11, 1995</b>	<b>Apr 12, 1995</b>	<b>Apr 13, 1995</b>	<b>Apr 14, 1995</b>
Investigation B : Sudents would attempt 	Students report to the class on their project 	Student post-test 		
	team project design of insulation method to 			
<b>Apr 17, 1995</b>	<b>Apr 18, 1995</b>	<b>Apr 19, 1995</b>	<b>Apr 20, 1995</b>	<b>Apr 21, 1995</b>
<b>Apr 24, 1995</b>	<b>Apr 25, 1995</b>	<b>Apr 26, 1995</b>	<b>Apr 27, 1995</b>	<b>Apr 28, 1995</b>
<b>May 1, 1995</b>	<b>May 2, 1995</b>	<b>May 3, 1995</b>	<b>May 4, 1995</b>	<b>May 5, 1995</b>
<b>May 8, 1995</b>	<b>May 9, 1995</b>	<b>May 10, 1995</b>	<b>May 11, 1995</b>	<b>May 12, 1995</b>

Figure 6: Project chronology

Since the schedule for using the computer lab was inflexible, these delays reduced the actual time spent from the planned allotment of seven or eight days to four and a half days.

Practically speaking, the delays made it difficult to "generate momentum" early on, and made the presence of the driving question as a type of organizer even more important.

The teacher allowed the students to choose their own groups. The size of the computer lab (16 stations) meant that group sizes were limited to two students each. In anticipation of the need for a classroom heat source, the teacher also purchased a small microwave oven.

### *Learned Curriculum and Observations*

Marx, Blumenfeld, Krajcik & Soloway (1997) describe how classroom partnerships between teachers and researchers are developed via theoretically congruent practices. An example of such a practice is the plan that was worked out for determining the role of the researcher and the teacher. It was determined that the researcher would have a visible pedagogical presence, and would interact in the classroom as a teacher aide. The teacher would direct the class, and surrender the "chair" to the researcher when he felt uncomfortable from either a procedural or content standpoint. Part of the reason for doing this was to give the researcher some leeway in integrating what was needed for this study in terms of research design, and part was some unfamiliarity from the teacher with the content and the practice of project-based science. The teacher always maintained an active role in helping students who he perceived were having difficulty with a concept or with the software. From the very beginning, the students were told that they were involved in a university research project, and that their involvement was voluntary. No student expressed reservation or reluctance about participating in the project to the school administration, the teacher, or the researcher, and parental feedback regarding the project ranged from neutral to positive.

Several of the experiments performed in this section required the use of special tools such as a blowtorch, laboratory standard, tongs, etc. Some other "esoteric" equipment was also utilized, such as a temperature probe intended for use in one's ear. For many of the students, this was the first time they had ever used such things, especially in front of an audience. Thus, the amount of confidence they had in their ability to manipulate these tools had an appreciable impact on their willingness to participate.

The students had been keeping a notebook through the year-to-date of papers, notes, etc. Their observations and ideas regarding the energy conservation experiments were written and kept in these notebooks for later reference, along with the formal definitions of the first and second laws. In fact, the students did refer back to the definitions at times when answering questions posed within ELabBook. In future versions of this project, it would be useful to collect and perhaps briefly assess student learning and understanding of the concepts introduced here. While neither the teacher nor researcher discerned a systematic failure to grasp these concepts, the performance of some students on the posttest and in interviews shows that some did indeed fail to grasp.

### **How do you measure heat?**

The second sub-question to be addressed is "how do you measure heat?" This section affords a greater opportunity for student experimentation than the previous one. It also is where students who have a difficult time distinguishing between heat, heat energy, and temperature get



a chance to see that how the constructs are related but unique. An expanded view of the section of the project map shown in Figure 3 that pertains to "how do you measure heat?" is provided in Figure 7.

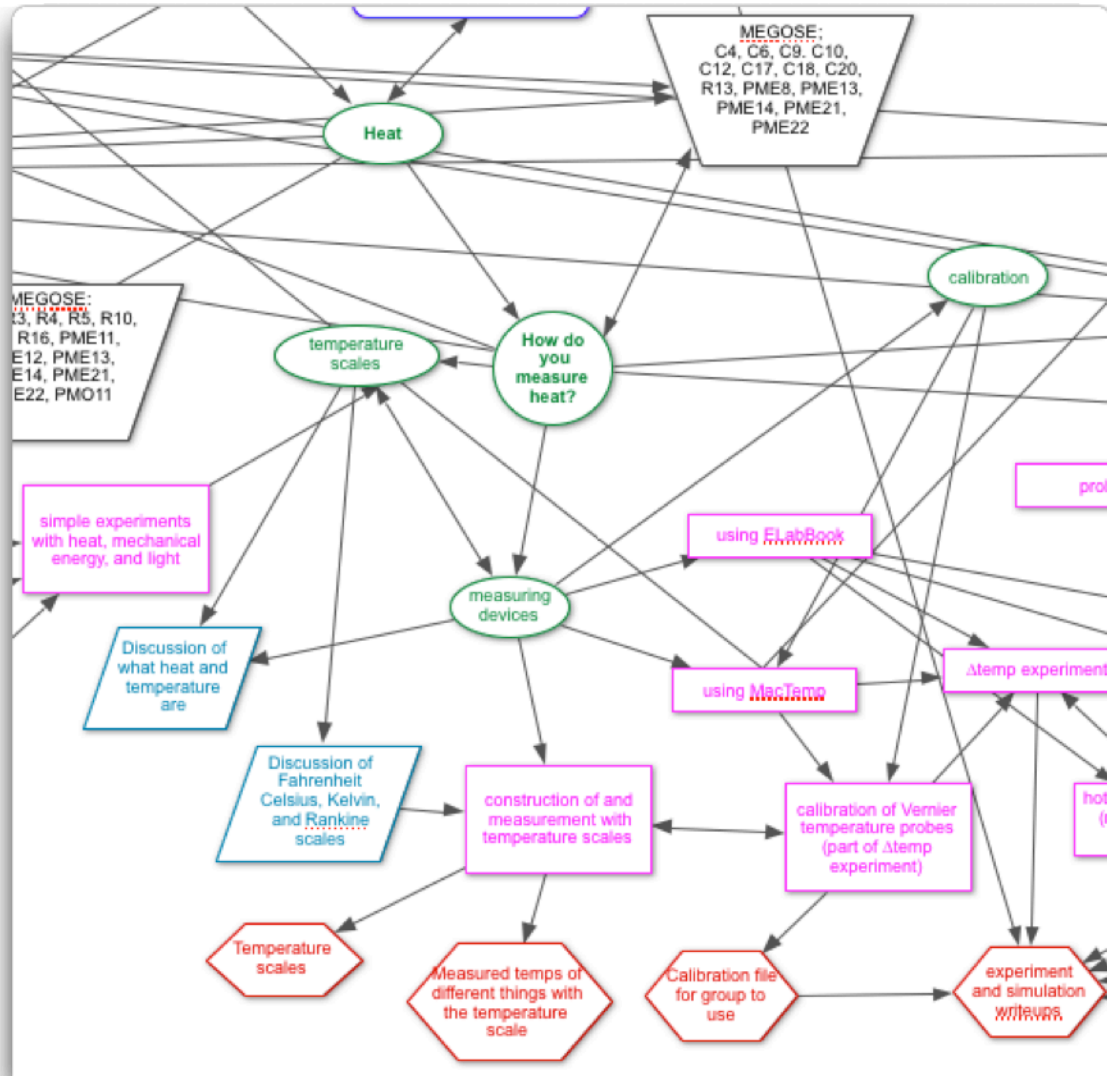


Figure 7: Expanded view of "How do you measure heat?"

### *Intended Curriculum*

The three principal content areas to be explored are Temperature scales, Measuring devices, and Calibration. *Temperature scales* is where temperature is introduced formally as a measure of:

"the ability of one body to give up heat energy to another body" (Standard Educational Corporation, 1983, p.H-111)

This formal definition of temperature is perhaps the most difficult of all for an eighth grade student to fully comprehend, hence it was not used as a working definition. Rather, the working definition of temperature is a common way in which heat is measured, in the same way that mileage is a common way in which distance is measured. This definition is supported in part by a class discussion of temperature and temperature scales. Each of the four most common temperature scales were devised for a specific reason, and discussing with the students how temperature scales serve a utilitarian purpose helps them understand that heat is the phenomenon of interest and temperature is how it is measured.

This would naturally lead into the question of how one measures temperature, and thus the topic of *Measuring devices*. The two types of measuring devices discussed are analog ones such as thermometers and digital ones such as electronic voltage sensors. Different categories of devices, such as those used for high temperature applications (cooking), narrow range applications (oral), and all-purpose use (laboratory) are discussed. In this unit, the students perform their first extended (two-day) experiment, where they are asked to devise a temperature scale on an unmarked alcohol thermometer. On the first day, the students record temperatures of interest on the thermometer, such as room temperature, ice temperature, body temperature,

boiling water temperature, etc. On the second day, the students are asked to measure the temperature of a material, and make a prediction as to what that temperature would be in either Fahrenheit or Celsius. This experiment forces them to do some manual calibration of their scale. The cognitive goal of this calibration is not to have the students generate least-squares equations or perform error analysis or goodness of fit tests. Rather, presuming they are capable of spatial linear interpolation, the goal is to give them insight into "where the numbers come from." They see from their scale that the value of the number is based on comparison, so that relative rather than absolute magnitude is of greatest interest.

From there, the students move into the computer lab and investigate *Calibration*. Calibration of electronic sensors requires a greater understanding of what one is engaged in, because the computer is incapable of producing the sort of autonomic elaborations that the students performed when using the unmarked thermometers. Instead of "instinctively" calibrating manually, the students have to "teach" the computer how to calibrate, and further inform their own understanding in doing so. In order to teach, they must understand some basic concepts such as the notion that one can only place confidence in a data measurement that falls between upper and lower calibration measurements. MacTemp and ELabBook each require some sort of calibration procedure where the students perform a calibration of two temperature probes. They would use that calibration for all of their future experimentation, so that the accuracy of their future results depends on the care taken for calibration. The calibration file is an example of an electronic artifact.

### *Enacted Curriculum*

The project plan described had to undergo some changes as a result of the delay described in the previous section. A fixed date that developed was a period of time in which a researcher from the CLP team would be present at this site to observe and render aid as the students began to use ELabBook. Therefore, it was important that the first ELabBook investigation was begun on that day. He suggested that the potato demo, which was a pared down simulation, be used to introduce the students to the program as opposed to calibration. It was thus decided that the classes would not have the luxury of performing calibrations with both MacTemp 3.04 and ELabBook, therefore only the one with ELabBook was attempted. It was also decided that the ELabBook calibration would take place at the time of the  $\Delta$ temperature investigation undertaken while addressing the question, "How does heat behave?" The description of the ELabBook calibration is provided in this section even though the actual calibration was performed with the investigations described in the following section.

One of the difficulties involved in executing these experiments was the lack of suitable "analog" equipment on site at the school. For example, both marked and unmarked thermometers were brought in from the university, as the school itself had few marked ones and none unmarked. The unmarked thermometers were alcohol-based, with an upper bound of approximately 50°C and a lower bound of approximately -10°C. There were only enough for a class full of students groups, so that thermometers were shared from class to class. Each thermometer was placed in a molded plastic sheath; the sheath was used to make calibration marks. The marks were wiped away after each class.

The unknown material used for the measuring device investigation was canned clam chowder. The appeal of using this material was to allow the students to eat it after making their final temperature measurement (the soup that was used for the experiment was physically distinct from the soup that was eaten). Portions of clam chowder were heated in a microwave oven until a temperature of approximately 45°C was attained. A bowl of chowder was given to each student group, and they made a measurement with their thermometer at the same time that a laboratory thermometer was used to record the temperature in °C by the researcher. The students then went back and estimated the temperature, and received the number recorded by the researcher in order to make a comparison. All of this information was written into their notebook.

The measuring device investigation also revealed a classroom feature that had not been well anticipated - what to do when a group is absent for the first day and has to play "catch-up", or is absent for the second day and doesn't complete the work. This issue played an even larger role when the students were using ELabBook, and was never clearly resolved. Part of the problem was that there was no mechanism for allowing absentee students to perform a tool-based investigation outside of normal school hours. Another part was the fact that it was considered acceptable among most peer groups for the students to take a "zero" rather than attempt to complete their work.

The researcher from the CLP group, encapsulating their reticence to include calibration and measurement into the curriculum, expressed concern that the students would be unable to grasp the concept. He also expressed a warning that it might take three days to allow the students

to familiarize themselves with ELabBook rather than the half-day that was planned. He was surprised to see how well these students were able to navigate the Macintosh OS, stating that they were "way ahead" of the students in Berkeley in this regard. However, it did take the students two or three full days to learn to make their way around ELabBook and complete the demonstration simulation that had been prepared.

Part of the slowness stemmed from the fact that the computers had slightly outdated central processing units (CPUs) and HyperCard-based stacks such as ELabBook are highly resource intensive. Throughout the remainder of the computer-based investigations this situation caused the price of errors and retries to increase, partially negating one of the unique advantages of the technology. Most of the students were used to the speed of contemporary CPUs, and often expressed frustration with the slowness.

The CLP researcher also took the time to provide instructions to the teacher, researcher, and students on how to take advantage of the networking capabilities of ELabBook. At the time, even though the stations were networked, ELabBook was being utilized as an application that would stand alone on each station. The plan was for intergroup collaboration during simulations to take place orally. He suggested that if a server-client configuration were established, then two advantages would come about; first of all, the students would be able to work on any station to access their data, rather than have to return to the same one each time. Second, each group could poll a group at another station electronically and receive an answer; a group could also send another group a screen copy of their data. At first, the students enjoyed sending superfluous

messages about, but after the novelty wore off they only used the feature when they were on-task.

### *Learned Curriculum and Observations*

Marx, et al (1997) talk about the challenge for classroom teachers to rethink classroom control issues - not just management and "behavior control" but also control of type and complexity of information. Prior experience with this teacher showed that he had a satisfactory ability to manage group classroom work. He showed a willingness to allow the students the opportunity to collaborate and talk, even though the students often lacked the maturity, the motivation, or the self-discipline to remain on-task. The area of information control was admittedly more difficult for him to let go of, even though he showed considerable ability for providing clear, comprehensible explanations. Throughout the project, he struggled with the idea that the students should learn by exploring rather than by hearing, and that struggle began with all of the work on manual calibration.

A holistic examination of the students' manual calibrations showed that roughly half of the groups arrived at a clam chowder temperature that was reasonable. Of the rest, some were wildly incorrect but a large number simply gave no answer. This was reflective of yet another trend that emerged throughout the project, and that was the inability of several students to attempt an answer. Classroom observation of these students indicates that lack of either intrinsic or extrinsic motivation was the clearest cause, where the precursor of that lack is not clear. Previous observations of this trend at this school is what contributed to the addition of the

percentage of completed work and the number of words written as data that would potentially help indicate student motivation.

In performing the ELabBook calibration, it was discovered that the software lacked a key feature that was present in the first generation MBL. In the first generation, one could perform a calibration and save the calibration file under a specific name. At future times, that calibration file could be specifically requested, so that each group could work with their own calibration file, and perhaps live with the consequences of a job poorly done. With ELabBook, only one calibration file could be saved at a time, so that all the groups who used a particular station used the same calibration. It was incumbent upon the teacher and researcher to make sure that each calibration was done correctly, since a poor job would put "the innocent" at risk.

It was mentioned previously that the students would fully learn the nuances of calibration by having to "teach" the computer. Many of the student groups showed the same systemic tendency when given two probes to calibrate. Often they would put one probe into a warm bath and the other into a cold bath, believing that they were sufficiently bounding the problem. They would then be asked to reason whether this was the right path to take. Some resistance to having to reason about such a thing was made, but the students eventually showed that they were capable of understanding if they gave the effort. At other times, the students showed some confusion about how to discern a stable reading in a warm bath, since the temperature of that bath inevitably began to drop. This was the sort of problem that only experience could help with, as there is no algorithm for precisely determining when a stable calibration has been achieved.



An interesting "sign of the times" occurred during the investigation of measuring devices. One of the possible calibration measurements was one's own body temperature, which could be taken either orally or under the armpit. The students in the classes showed some reluctance to touch the thermometers used in the previous classes out of an ill-defined fear of contracting AIDS - even though the thermometers were thoroughly cleansed with antibacterial tissues between uses.

### **How does heat behave?**

The third sub-question to be addressed is "how does heat behave?" It is here that the students discern the knowledge needed to successfully respond to the driving scenario. It also is where the students fully utilize the features of ELabBook for simulated and real-time data measurement and analysis. An expanded view of the segment of the project plan shown in Figure 3 that pertains to "how does heat behave?" is provided in Figure 8.

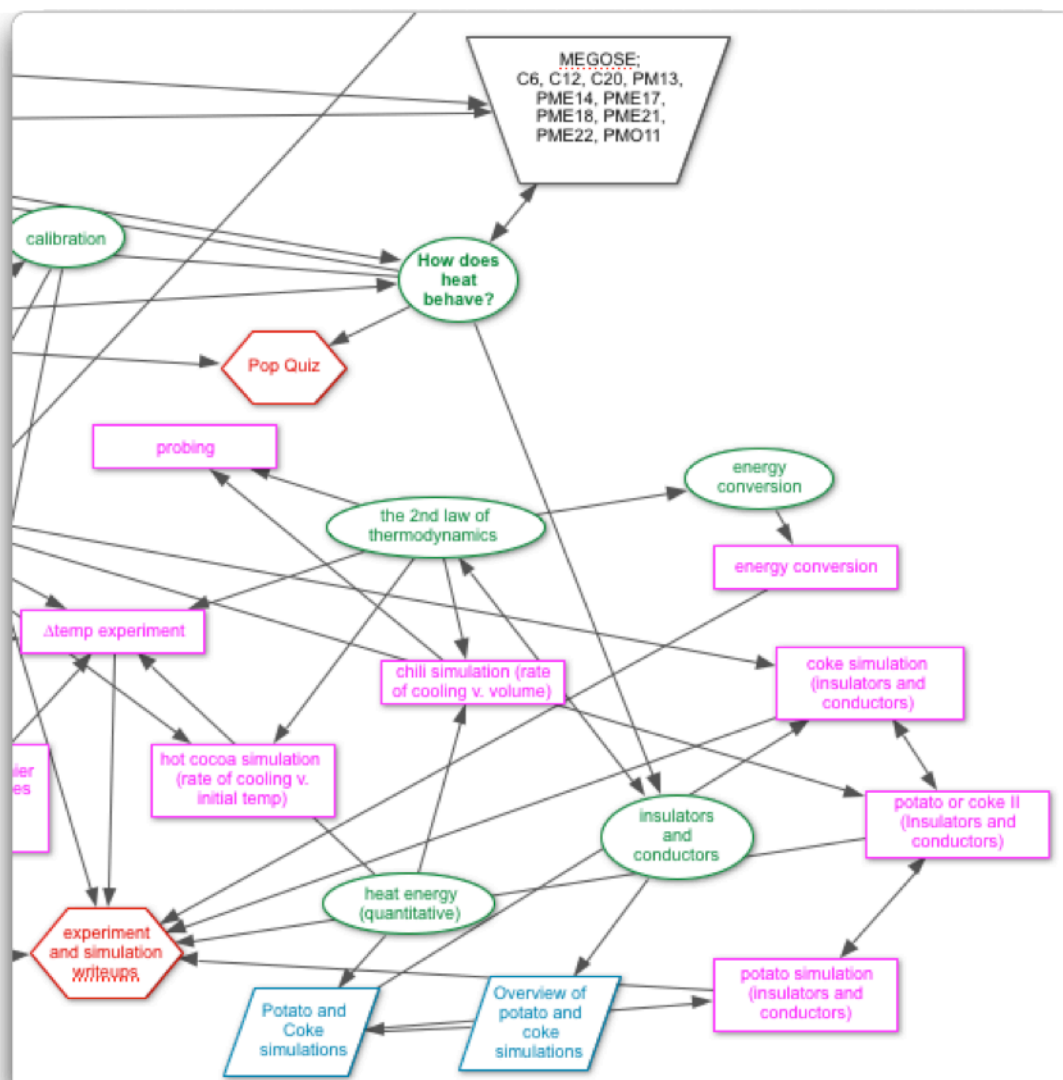


Figure 8: Expanded view of "How does heat behave?"

### Intended Curriculum

The content addresses the laws of thermodynamics with emphasis on the second law, the efficacy of various materials for insulating and conducting, and some simple calculations involving heat transfer rate and specific heat. The list of concepts includes *the second law of thermodynamics*, *Energy conservation*, *Insulators and conductors*, and *Heat energy*. The investigations supporting the content related to this question consumed the largest time period

during the unit. Each of the investigations utilized either ELabBook or MacTemp, primarily ELabBook. The major artifact of student effort comes in the writing of the electronic lab reports.

Each simulation or experiment asks the student group to consider and write:

- The objective of the lab;
- A prediction of what will occur;
- An analysis of what was observed or measured, including graph interpretation and relating the graph to the scientific phenomenon, and constructing the governing scientific principle;
- A discussion and verification of the results by comparison with the results of other groups and with the group's previous experiments; and
- A reassessment of the prediction, reviewing its accuracy, and formulating a summary of what was observed.

The content of *the second law of thermodynamics* was supported by four different investigations. The probing investigation involves the students in predicting and measuring the temperature of different objects in the room. This forms a basis for discussing the concept of thermal equilibrium in a closed system, along with a rationale for why objects at the same temperature feel warmer or cooler when touched. The chili simulation involves the students in examining the effect of volume upon heat transfer rate, and the hot cocoa simulation does the same for initial temperature. These simulations set the stage for the temperature  $\Delta$  investigation, which involves the students in seeing the effect of different volumes on the rate of heat transfer between two objects in contact. The graph produced from this experiment provides the students with a pictorial representation of the second law of thermodynamics. Furthermore, a heat flow analysis of this experiment helps the students understand that heat transfer is a dynamic process that proceeds in different directions at diverse times.

*Insulators and conductors* was where the students develop an understanding of the fact that materials function equally well in keeping objects warm and cool, and construct a hierarchy of the insulating value of different materials via collaboration. The investigations consisted of ELabBook simulations with potatoes and cokes. In the first simulation, the students chose any two of six materials (aluminum foil, wool, styrofoam, saran wrap, paper, and nothing), and predict and observe which wrap is most successful in keeping a potato warm over a short period of time. In the second simulation, the students used the same two materials and predicted and observed which wrap was most successful in keeping a coke cool over a short period of time. The students were able to determine which of the six materials were the best insulators by comparing their results with those of other groups. They also began to see that the insulating value of materials maintains a relative order regardless of whether they are used to keep something hot or cold. In the third simulation, the students chose a new material to compare with one of the "old" materials, and picked either a potato or coke simulation as the venue for comparison. Each student group got a quantitative feel for ordering three materials by insulating value, and were able to find out about other materials by talking to other students. They were not asked to rank the six materials as part of an assessment, because that knowledge was to be displayed later on in the construction of the passive insulating devices.

*Energy conservation* is where the students took a quick look at the first law of thermodynamics. The energy conversion investigation involved the students in an investigation of the effect of color on the absorption of energy from a light source. In this experiment, students measured the temperature of two bins of dark and light colored sand over time as they were

exposed to a common light source. Some of the students had the opportunity to use other colors. The investigative format resembled the simulations.

*Heat energy* involved the students in performing some rudimentary mathematical calculations using the steady-state heat transfer equation,  $\Delta h = mc_p \Delta T$ . The data for these calculations came from the students' own investigations. For each of the simulations and experiments performed, the students would do a heat transfer calculation. This was done in a whole class discussion format. There was also a whole class discussion where the heat flow diagrams for each of the investigations, especially the temperature  $\Delta$  experiment, were constructed.

### *Enacted Curriculum*

Twice a day, the teacher and researcher held a debriefing session where the day's events were summarized and discussed. The related issues of attendance and lack of cognitive partnership were often revisited during these sessions. During these meetings, notes were kept about what appeared to work and what didn't, decisions were made about whether to deviate or adhere to the project plan the next day, and strategic planning was made for assessing the final artifact of the project. These debriefing sessions were important for insuring the integrity of the working relationship between teacher and researcher. The teacher and researcher also stayed in contact with two CLP researchers – programmers - via electronic mail. This provided a convenient means for discussing procedural questions and resolving problems stemming from errors or accidental misuse of the software.

Several of the other science teachers in the school were aware of the nature of this project and either apportioned or ceded their lab time. Thus, the eighth grade students had nearly three weeks of unobstructed lab time split into two major blocks, a nearly unprecedented allotment. Between institutional absenteeism and a propensity for students to take longer to move through the simulations and experiment, the number of ELabBook investigations was reduced to five: a potato demo, the potato simulation, the coke simulation, a second simulation with either the coke or potato, and the temperature difference experiment. A hot cocoa simulation that was typically part of the set of simulations performed in the CLP was not included in this unit. Pretest results indicated that many of the students already knew about the effect of material color on absorption and the effect of volume and surface area. Regarding the effect of initial temperature, the researcher mentioned the idea that hot water placed in an ice tray will freeze faster than cold water, and was met with incredulity and skepticism from the students. Their conclusion that this was unlikely gave sufficient evidence that the hot cocoa simulation was not necessary.

During the computer sessions, some *in situ* adjustments were made to the project plan. For example, after the students had done several simulations, it was decided to precisely replicate two of the simulations with experiments, in order to allow the students to conclude whether the data from the simulations were reliable. It also provided an opportunity to address the concern previously noted about thermal diffusivities and the issue of material thickness. The class watched as the researcher carefully wrapped 256 layers of aluminum foil around a potato and a can of cola, in order to match the thickness of a wool sock enveloping the same. This class activity had the added dimension of modeling for the students how an experiment would be done and where they might acquire materials for their insulating devices. The researcher used one of

his own wool socks, which stimulated some of the students to appropriate a sock from a father or older brother (often unbeknownst to the owner) when searching for insulating materials for their device, a blending of household and school knowledge reminiscent of the concept of funds of knowledge (Gonzales, Moll and Amanti, 2005).

An unanticipated dilemma emerged when it was discovered that several of the MBL units were either missing or not working. Eight working units from the school were confirmed, and four more were borrowed from the university. The shortfall meant that in one class, one of the groups had to be disbanded and scattered for the temperature  $\Delta$  experiment. It also meant that no spare MBLs were available; however, no catastrophic equipment malfunctions occurred.

A pop quiz was added after the students had done all of their ELabBook simulations and experiments in order to assess whether individualized learning was an outcome of the group work. This pop quiz was structured so that it allowed the students to revisit fundamental observations made during the simulations and experiment. A whole class review of the pop quiz was undertaken with particular emphasis on helping the students construct a heat flow diagram.

### *Learned Curriculum and Observations*

As mentioned previously, the following scenario repeated itself many times: one member of the group is either chronically disengaged from the task or is absent, or group members appear to take turns being absent. Therefore, either the remaining member(s) of the group do most of the cognitive work, or one member of the group finds that he or she is unwilling or unable to reconstruct the progress made in their absence. This is especially distracting to learning when

there is a sequence of investigations that build upon each other, such as the potato, coke, and potato/coke II set. Students had the opportunity to schedule time after school, during lunch, or before school to make up time, but the idea of doing such a thing was not part of the school culture.

It was agreed between the teacher and researcher that a potential variable of interest indicating student motivation is attendance. Middle school students may easily find a reason not to attend school or even a particular class. It also has a direct impact on what they learn, since they obviously cannot master what they don't experience. The teacher believed that attendance picked up for the computer sessions and for the device testing.

During these investigations, the students found themselves confronting some of the alternative conceptions they possessed regarding the insulating value of materials. Many predicted that aluminum foil would surpass other materials for keeping potatoes warm or for keeping cokes cold. They cited instances where at restaurants, baked potatoes were wrapped in aluminum foil to keep them warm, forgetting the fact that many times these potatoes were warmed by a local heat source. They also recalled times when a relative or friend wrapped a can of coke in aluminum foil to help keep it cold while they went on a picnic, to school, or other outing. Gradually, they came to accept the notion that aluminum foil was not well suited for insulation. They also accepted the idea that wool could keep objects cool as well as they could keep the warm. A notable incident demonstrating this occurred when one of the students began using her father's wool socks as a wrap for keeping her coke cool until lunchtime. The simulations and the discussions they held about the simulations served as the basis for this



conceptual change, as the efficacy of insulating materials was not "covered" in whole class discussions or hinted at with the ELabBook prompts.

E LabBook was introduced at this school two years prior to this, and was quickly dismissed by the staff as "too buggy" to use in the classroom. During this implementation, the usefulness of the software as an educational tool became more apparent, such that early on the teacher noted the improvement from the previous time along with a willingness to make E LabBook a permanent fixture in his teaching. Some concerns about the software interface were evident, such as its tendency to stray from the Macintosh Human Interface Guidelines (Apple Computer Inc., 1993) with respect to what looks like a button and what doesn't and the functionality of menu items such as "Print." A list of such concerns was forwarded from the school site to the CLP developers. The CLP developers either explained their particular reason for why the software worked as it did, or agreed that a better way was possible.

Appendix D contains screenshots from the use of E LabBook during this project, for both the teacher interface that was used to set up the scaffolds to be implemented for the investigation and the product of that interface design that was used by the students. Stern (2000) has some very good screenshots of both the teacher and student interface as well.

### **Answering the Driving Question**

The final stage of the project involves the construction, testing and successive redesign of the insulating devices. An experimental station was designated in the classroom, and the students

were encouraged to submit as many different designs as desired. The best design from each group is the one that results in the smallest temperature change. A class-averaged  $\Delta T$  was also calculated for each class, with the "winning" class being allowed to have a pizza party for lunch.

### *Intended Curriculum*

After the conclusion of the ELabBook investigations, the students were provided with several days of classroom time to work on their design. The test configuration consists of a large cooler full of water from -1 to 5°C. Inside the cooler is an aluminum canister approximately 10 inches long and nearly six inches in diameter. This canister is to contain a smaller 11 oz. aluminum can or soup can. The toroidal area can contain any sort of material arrangement, the only stipulations being that a way to fill the interior can quickly with hot water must exist and that a temperature probe will be inserted through their device. No hints about design features were given, so that the students were free to make their own determination of what would work best. No constraints on the amount of discussion were erected.

Each test was conducted in the following manner: the students affixed their insulating device to the interior can to their satisfaction. Once they were ready, they notified the teacher of their intent to test, and entered a queue. When their turn was ready, they placed their device inside the exterior canister and made all necessary adjustments. Approximately 11 ounces of water at ~75-80°C was placed in the interior can, the probe was inserted, and one of the students held the canister down to keep it from floating. The lid to the cooler was closed as much as possible, and a second temperature probe inserted into the ice water. When the temperature of

the hot water reached 70°C, a five minute countdown was initiated. At the end of five minutes, the students recorded the temperature of the hot water and calculated the temperature difference.

The germane design features of the insulating devices were anticipated to be:

- The predominant use of styrofoam, wool, and perhaps air,
- Insulation which extends in all three dimensions and a somewhat rigid lid, and
- A seal of all penetrations.

The students were free to observe any and all tests. At the conclusion of testing, each student group would prepare and present a brief talk to the class where they would describe their design and remark upon the rationale for design changes. A posttest would then be administered along with an interview for the same 31 students as before, in order to quantify and qualify the change in thermodynamics understanding that took place.

### *Enacted Curriculum*

During the course of the project, the teacher had asked the students to draw blueprints for their device replete with material lists and ideas for where to obtain the materials, and had them store these papers in their class notebooks. Every time a design change was made, whether the device was constructed or not, the students were asked to note the change on paper and save it.

Parts of the design testing process were recorded on videotape for posterity. A digital camera was used to record a picture of each student group with their insulating device. MacTemp was used to measure the temperatures because it was simpler and faster to use and there was no need for the more intense scaffolding within ELabBook. For each group, a poster was made

consisting of the group picture, the graph showing the temperature change, and the magnitude of the temperature change. If a group made more than one device, the magnitude of the change and a brief textual description of the device was appended to the poster. Throughout the testing process, a running score of everyone's data was kept so that the students would always know where they and their class stood relative to everyone else. It was hoped that doing this would encourage some of the groups whose devices resulted in large values of  $\Delta T$  to submit new designs.

The decision was eventually made to not have the students make presentations. Part of the rationale for doing this was a limitation on class time for the remainder of the term, given that a large group of students would undergo interviews that were to cumulatively span one week's time. Approximately one-third of the groups did not submit an insulating device, therefore a large group of students would have nothing to talk about. The purpose of this presentation was to stimulate discussion between the students about what they had done. However, it was clear that many such discussions had occurred, and the teacher and researcher concluded that those who had taken an interest in the project had been given ample opportunity to demonstrate it.

For a group artifact, a difficulty remained in determining the extent of the cognitive partnership within the group. It was thus decided to survey the students at the end of the project about the breakdown of their and their partners' contributions to the total effort. They were also asked to list the salient features of their design, and to ascribe the source for those features. This would provide information about how important a role input from peers, group members, and other sources such as family played in the students' decision-making.

### *Learned Curriculum and Observations*

Observations of the evolution of the design process gave certainty to the idea that the students were doing a lot of communication both inside and outside of class. The design process followed three phases. The very first group to test a device ended up in a three-way tie for first place among all the students. The group included all of the salient design features elaborated earlier. However, the only feature that emerged as important was the use of styrofoam and wool. Using styrofoam and wool would move students just into single-digit temperature changes, but stayed near the higher digits. This first wave of designs exhibited two-dimensional thinking, in that lids and bottom-end insulation was not included. When lids and bottom-end began to be included, students found that they could halve the temperature changes. However, nobody could quite reach the standard set by that first group until the idea of sealed penetrations sunk in. At that point, two other groups matched this first group, and others stayed close behind. As the testing deadline approached, a third wave of devices dubbed the “kitchen sink” designs were submitted. The moniker reflects the researcher's belief that these students had little clue about a systematic design philosophy; instead, they used any and every material that was recommended to be successful in insulating arrangements that were clearly haphazard.

In one of the classes, many of the students were members of a special education group that was “mainstreamed,” a practice at this school which means that these students were enrolled in the same classes as general education students, but were accompanied to the classes by their special education teacher who was able to understand the lessons that the students received and were better able to provide needed assistance to learn the material. Two student groups stand out

from this class because they share a common story. In one group, both of the students were part of the special education group; the other group consisted of a special education student and a "normal" one. For each group, the members appeared to be best friends. Each of the groups appeared to demonstrate reasonable understanding of the subject matter, and appeared to grasp the use of ELabBook. During the Easter vacation that the school enjoyed prior to device testing, one student from each group left school for the remainder of the term. After vacation, the remaining member of each group showed no inclination to construct and test a device. These remaining members quietly withdrew from participation for the remainder of the project.

One major change that should be implemented in future versions of this project is to have the students describe their design process more carefully. In addition to blueprints and material lists, it would be instructive to ask the students to write short paragraphs describing their design rationale.

A brief list of insulating materials used includes:

- Styrofoam, foam peanuts, packing foam,
- Wool socks, wool scarves, wool yarn, wool sweater,
- Cotton shirt, cotton socks,
- Aluminum foil,
- Fiberglass,
- Bubble gum,
- Duct tape, masking tape, scotch tape, and
- Saran wrap

## Summary - Teacher Comments

The purpose of this chapter has been to provide a picture of the classroom environment and curriculum used for this study. In order to provide an account of this study from the perspective of the teacher, the following first-hand summary is offered:

*The winter of '95' was my first full commitment to PBS in my classroom. I had tried other experiment-based approaches before but nothing on quite the same scale from the start to finish of a unit. My students' reactions to project-based science far exceeded my wildest dreams. At first I was skeptical about how successful this project was going to be for a number of reasons. To start with, we were attempting to cover a number of concepts in the area of thermodynamics. This is definitely not a real high interest area for your typical eighth grader and probably not a lot of adults either. Another reason was the number of at-risk students in my classes--students with high rates of absenteeism, lots of emotional problems, and generally turned off by school. In addition, I normally have an inclusion class as one of my assignments. This class includes approximately 50% Special Education students. Considering these circumstances, I really didn't know what to expect.*

*We started by doing a number of experiment simulations in our lab and on computers. This was to get the students thinking in terms of how they thought HEAT behaved. We also had several discussions involving their concepts of the behavior of heat in different situations. Numerous and widely held misconceptions came out, such as the idea that wrapping a cold pop in aluminum foil would keep it cold. All of this eventually led to our driving question/scenario of "You are a member of a R &D team whose job it is to reduce the heat loss of a body of hot*

*water in a hostile environment (ice water)." We placed a small can filled with hot water inside a larger can situated inside a large cooler filled with ice water. The temperature of the ice water was less than 1 degree C. We ran this for 5 minutes using MacTemp to record their results. The students had to plan what to do with the space in between the two cans to insulate the hot water in the small can against losing heat. They had to devise different methods of insulation using their earlier experimentation for reference and ideas they generated as a team.*

*After the first team made their initial trial run (the first of 5 they would eventually make), a competitive element emerged throughout all of my classes and the challenge of the project really took off. Students who seldom took any interest in school and were absent much of the time suddenly became interested in and excited about science class. Some students even attempted industrial espionage. When they heard of other teams' results, even teams in other classes, they tried to find out what those teams were doing. They would work on me trying to get me to reveal the other teams' methods. When they realized they were REALLY allowed to use their own ideas, not just instructions from me or a textbook, they went to work on an amazing variety of materials and experimentation. If I hadn't seen it myself I would not have believed it! If someone else had told me that these students, who were normally so apathetic about school, would have reacted to such a project in this way, I would have been VERY skeptical. This is what you hope for and strive for as a teacher, but the students' response went beyond even those aspirations.*

*There were several ways in which this project and my students' response exceeded all my expectations. One of these was the reaction and accomplishments of the students in my inclusion class. They went wild with this project. Every day I was constantly rushed by these kids to turn them loose with their experimental designs. I found them revising these designs verbally even as they were testing an earlier design. After the first round of testing this class had the best trial times of all my classes! I can still find some of their blueprints in books and cubbyholes in the room. The second area of amazement for me was the drop in absenteeism I*



*was seeing in all my classes, including a number of students who were chronic truants. A few even had their parents bringing them to school half way through the day so they wouldn't miss Science. Talk about speechless parents! The third item involved one student in particular. Her openly voiced ambition was to have a baby and that school was just getting in the way. This project brought about a startling change in her attitude toward school or at least about science class. You can imagine my surprise to find her bugging me, on a daily basis, to let her get started with her labs. All of a sudden she had science questions she wanted to answer and/or test. Not only was she coming to class, she was interested and involved.*

*The end result of all this for me has been a lot of redesign work on my other units. The reactions, the enthusiasm, and the initiative shown by my students have energized me into revising some of my old units into projects that take advantage of students' ideas and teamwork. The astonishing and immediate turnaround I observed with many of my at-risk students in response to this project has demonstrated the value of this type of science instruction. I don't know how long this change will last but early indications show that this is the way to go for my students and for me. (Used by permission)*

The teacher's perspective on this project was also written up and published independently (Canty, 1996).

The next chapter will describe the research methodology and instruments, and address validity and reliability.

## **CHAPTER 4**

### **RESEARCH METHODOLOGY**

In this chapter, the research methodology for this study is presented. This includes a description of the types of variables needed to illuminate the research questions, the research design and threats to validity, and the various data measurement instruments used.

The underlying issue being investigated is whether eighth grade students in a diverse school environment undertaking a project-based thermodynamics science unit and using a well-regarded technology tool with scaffolded learning support were able to learn science. As stated in chapters one and two, the four specific research questions are as follows:

- Did student understanding of thermodynamics increase, given this particular classroom environment and high effort in the use of technology?
- What motivational or scaffolded learning aspects (as identified in chapter two) of the technology played the most important role in increasing understanding?
- Was the use of technology more academically motivating to the students? and
- What were the interactions of race and gender upon content understanding? What features of the study, including the technology, were most beneficial or detrimental to underserved students?

These questions are centered in the basic model for increased science understanding that has been proposed throughout this thesis. Figure 9 shows a different conceptualization of the basic model, with connections between the artifacts described in chapters three, four, and five

and the core variables in the model of prior understanding, motivation, scaffolded knowledge growth, and science understanding.

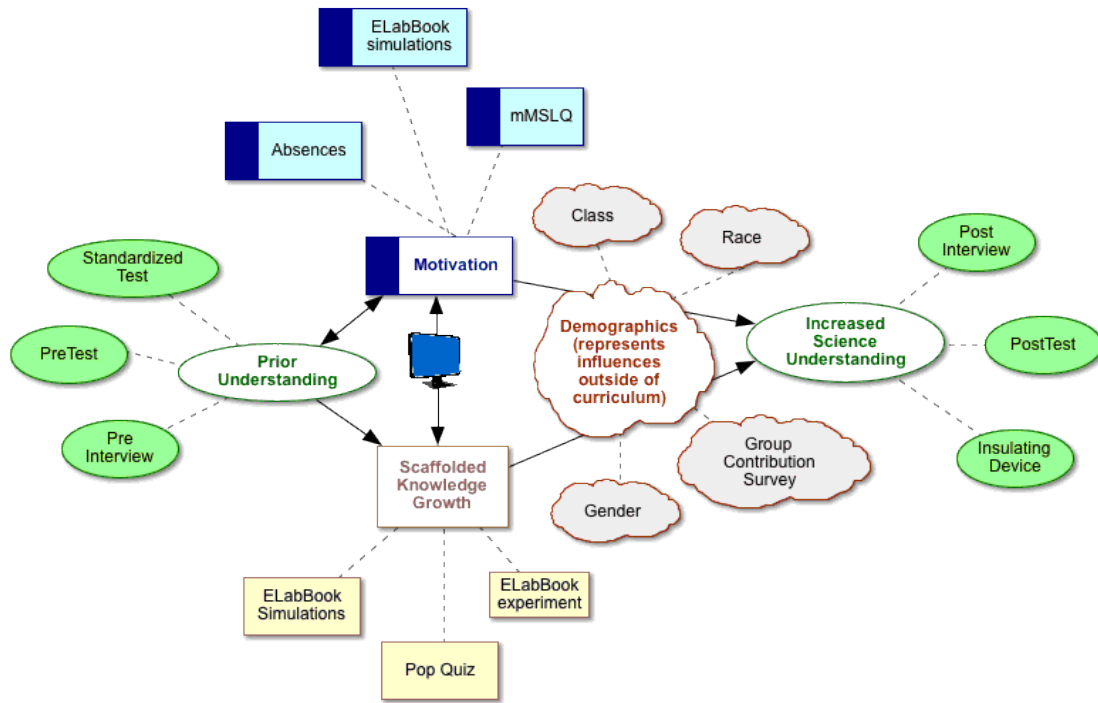


Figure 9: Basic model for increased science understanding showing connections between variables and artifacts.

The model has been proposed in earlier chapters as an association of independent variables, prior understanding, scaffolded knowledge growth, and motivation, that work together to increase science understanding, with possible influence from non-curricular influences represented as demographic variables. In Figure 9, the relationship between each variable and the artifacts used to measure that variable are shown. One of the purposes of this chapter is to establish these artifacts as reasonable measuring gauges of the variables.

The model – and this study – carries an implicit hypothesis that the dependent variable of science understanding does increase with input from the independent variables of prior understanding, motivation, and scaffolded knowledge growth. The rationale for each research question is to discover the effect upon each of these variables – did science understanding increase, how did scaffolded knowledge growth and motivation contribute to any increase, were there any differences in effects due to demographic variables such as race, gender, or class.

The above research questions are investigated by examining a sample population of eighth grade science students who are taught by the same teacher. The size of the sample population (N) is 103 students. Of these, 55.3% are white and 44.7% black; also, 53.4% are female and 46.6% male. The 103 students are split between four classes in the following manner: 26 (25.2%) in second hour and fourth hour, 23 (22.3%) in third hour, and 28 (27.2%) in sixth hour. A few students were enrolled in a given class at the beginning of the study but not at the end, and vice-versa. Some students were absent from class on days when an artifact was created, and some chose to simply not attempt or complete an artifact, so the actual sample sizes vary by artifact or artifact comparison but generally range around  $N \sim 90$  with the exception of the construction of the insulating device,  $N = 72$ , and students who were selected to participate in both the pre- and post-project interviews as explained in chapter three and later in this chapter,  $N = 27$ .

The primary data analysis and charting software used for this project is SPSS/PASW<sup>®</sup> Statistics Base with the Advanced Statistics and Regression packages. Additional data

preparation, analysis and charting was performed with Microsoft Excel<sup>®</sup>, iWork Numbers<sup>®</sup>, and AppleWorks<sup>®</sup>, with some older analysis from StatView+<sup>®</sup>.

## Setting

The setting for this study is a middle school in a racially mixed, "small urban" area of southeastern Michigan. The district consists of four elementary schools, one middle school, and one high school. It may be characterized according to societal factors of socioeconomic status and crime, and school environmental factors of achievement and organization. The variables that should be taken into account in identifying at-risk students range from "societal factors (e.g. poverty), school environmental factors (e.g. inappropriate curricula) and student factors (e.g. learning deficits or difficulties, low self-esteem)" (A. Palincsar, personal communication, January 29, 1995). This list is more generous than others would propose; for example, the Massachusetts Department of Elementary and Secondary Education (2011) has developed an early warning calculator for potentially at-risk students (one algorithm for urban schools, one for non-urban) whose data consists of standardized test scores in math and language arts, attendance rate, number of in-school suspensions, and the completeness of this data. Worley (2007) suggests other variables such as the quality of relationships with parents and caregivers, and even participation in athletics. However, the list suggested by Palincsar will be taken as a baseline.

In describing the makeup of these factors in this school district, no attempt is made to make a blanket statement along the lines of "every student in this middle school is an at-risk student."

Sagor's (2004) definition of the at-risk student, previously explained in chapter two as a person who is not on a successful path to possess both the skills and self-esteem to make meaningful choices in future stages of their lives, is more of a forecast based on personal knowledge or longitudinal research rather than something that can be discerned just from demographic information. However, some societal and schoolwise factors are worth noting.

### *Societal factors*

The school district is referred to by the State Department of Education as "out-of-formula", meaning that taxes and other locally-generated revenues are below a per student level set by the State Board of Education. The district also received "at-risk" funding from the State of Michigan; the dollar amount of such funding is based the number of students who qualify to for the federally funded free/reduced lunch program (K. A. Sexton, personal communication, April 11, 1996). Participants in this program are selected on the basis of family income, and the receipt of at-risk funding from the state is similarly based. The school district at that time had a participation in the free/reduced lunch program of about 50%, in comparison to a state average half that size, and a county average of 17% (Packer, 2001, p.254).

Shortly before this research study was carried out, a large automobile manufacturing plant located within the borders of the school district was permanently closed. This caused a depression in the local housing market due to the availability of homes for sale by workers who were reassigned to another state. This real estate depression had little effect on housing costs in other areas of the county, as most of the surrounding areas are relatively affluent. These

indicators suggest that the residents of this school district enjoy a below average socioeconomic status in comparison to the rest of the county and state.

Households, businesses, and other institutions in the district also experience an above average crime rate in comparison to the rest of the state. Crime statistics generated by the FBI from reports made by local law enforcement agencies have been accessed for the areas in which the school district is located. Out of 121 agencies reporting statewide, agencies located in cities and townships with a population of 10,000 or more, the crime index of the town where the district is located has a percentile rank of 78.7 (United States Federal Bureau of Investigation, 1993). Therefore, only 21.3% of agencies statewide reported a higher crime index (the crime index is proportional to the number of violent and non-violent crimes reported).

### *School factors*

The district historically experienced a below average degree of achievement on standardized science tests in comparison to the rest of the county and state. Table 1 shows an historical comparison between state, county, and district for a statewide standardized science test (Michigan Educational Assessment Program, or MEAP) administered to eighth grade students. The scores for 2010-11 and 2011-12 are included to show that the district has continued to have scores below that of the state. Cut scores in 2011-12 were raised considerably, hence the drastic reduction in proficient students from 2010-11. The students who were a part of this study are in the 1994-95 cohort.

Table 1

*Percentage of Students on the MEAP Achieving a Score of "Satisfactory" (proficient) or Better.*

Municipality	1992-93	1993-94	1994-95	2010-11	2011-12
State	57.1%	59.4%	61.7%	78%	16%
County	61.5%	62.5%	67.2%	n/a	n/a
School District	28.8%	27.5%	42.9%	61%	2%

Results on the state standardized science test for 8<sup>th</sup> graders in that school for the following year, 1995-96, showed that only 6.0% of students were scored as satisfactory (Packer, 2001, p. 254). This caused a bit of controversy, as the local school board called into question the validity of the improvement from 1994-95. The 1995-96 version of the test had undergone a qualitative change by the State that resulted in criticism from other districts for lowered scores.

In 1994-95, the school was in the final year of a five-year partnership where it functioned as a Professional Development School (PDS) for the University of Michigan. The Michigan Partnership for Education, a state government agency at that time, provided funding that was matched in part by the University to facilitate this arrangement. An important selection criterion for the cooperating school and district was that it allowed University faculty and staff to provide hands-on intervention in its administration, curriculum planning, and teaching. In essence, it was a school and district that admitted to needing help in these areas. In exchange for this intervention, the University was able to utilize this functioning educational institution as a type of lab school.



### *Technological factors*

A microcomputer lab was installed in the middle school for the specific use of the science department (Rubio, Canty, & Krajcik, 1993) in 1991, as the first educational effort in support of the PDS. Sixteen Macintosh™ LC and LC II computers were networked with two laser printers, and all were located in a wet science lab. The lab was available for shared use by the teachers on a rotating basis by grade, with each grade allotted three or four days in succession. The teachers in each grade then determined which class used the lab at each time. The school also had a computer center with 28 Macintosh LC 575 computers networked by Ethernet™, three dot matrix printers, a color ink jet printer, a laser printer, and a Macintosh Workgroup 95 server. A Power Macintosh 6100 multimedia computer with a color scanner and digital camera were also provided for student projects. Computer classes for all grades were held in this center. At the time, the amount of technology available to students was markedly higher than many other schools of similar socioeconomic character.

### *Teacher factors*

All of the teachers in the science department were involved in either the first or second tier of the development group for the project-based science (PBS) research group operating at that time. The first tier of teachers were those who were intimately involved in the initial formulation and implementation (Krajcik, Blumenfeld, Marx & Soloway, 1994). The second tier were those who became familiar with PBS through contact with the first tier. PBS research at the school began at approximately the same time that the school became a PDS. With this additional collaboration, the teachers and their students became successively more comfortable with the presence of university researchers in their classrooms. It was not considered unusual for the

students and teachers to fill out surveys or be interviewed or videotaped. The administration was amenable to university-sponsored classroom interventions such as this project.

The special education department at this time embraced a philosophy of inclusion, such that special education students were partially mainstreamed. The students were organized as a cohort. They took three out of four required courses - history, math, and science - with the mainstream of students, with their special education teacher and an aide accompanying them students to each class and moving from student to student in the class to facilitate understanding and study when working independently. This was the case for the special education students who were part of this study; they were grouped into the sixth hour class. The students then took their two elective classes on their own, with no additional support. Finally, they studied reading together in a resource room under the tutelage of the special education teacher.

### **Strategy**

In chapter one, it was noted that the research design for this study is that of a quasi-experiment that is time-dependent, one-group, and test-retest. The results and educational implications will be revelatory but not absolute. They are revelatory because of the uniqueness of the setting and confluence of the values of PBS and CLP. They are not absolute because one quasi-experiment of one group of students in one school taught by one teacher cannot be reasonably expected to generalize to *any* student in *any* school. However, they may be reasonably expected to serve as pointers, to guide future studies in this area. Thus, the results of this quasi-experiment are generalizable to a theory or proposition rather than a population.

Pre- and post-intervention measurements are made of the entire sample, in order to track aggregate changes in motivation and learning. In-situ measurements are used to help suggest when the change occurs. Some of the measurements are made at the level of the individual, such as classroom demographics, surveys, interviews, and quizzes. Some measurements are made of the group effort, such as artifact assessments, where the group effort is the sum of the contributions of the members of the group,

$$\bar{x}_{group} = \sum_i x_i, i=1, n \quad (1)$$

An effective measurement for each individual,  $x'_i$ , is then defined from the group mean,

$$x'_i = \bar{x}_{group}, i = 1, n \quad (2)$$

Eight data collection instruments have been designed or modified for use in this study. In addition to the data from these instruments, demographic student information including gender, ethnicity, standardized test (MEAP) score, daily attendance and semester science grades were obtained by permission of the school and teacher. Table 2 briefly describes these eight instruments and how their data are used in this study. The timeframe for administration of these instruments is included in the project timeline description given in chapter three. It was explained to the students by the teacher that he was using the scores from the science content surveys, pop quiz, and artifact assessments as part of the basis for their grade in the class, in order to promote their maximal effort and mindfulness.

Table 2

*Role of Various Data Sources*

Data Source	Description
Classroom Demographics obtained by permission of the teacher and school administration	Collection of student information: gender, ethnicity, standardized test (MEAP) score, daily attendance, semester grade
Student Background for Computer Use and Science-Related Activities Survey developed for this study	Report of student information: location, mode, and frequency of extracurricular computer use and formal scientific exploration used to determine prior knowledge and experience with computers
Semi-Structured Interview Protocol (pre, post) influenced by similar protocols (Krajcik, Layman, Starr & Magnusson, 1991; Songer, 1989; Lewis, 1991)	Oral representation of students' thermodynamics understanding and attitude and aptitude toward computers used to discern changes in thermodynamics understanding over the course of the unit
modified Motivated Strategies for Learning Questionnaire also called mMSLQ (pre, post) originally developed by Pintrich & de Groot, (1990)	Measurement of motivation such as self-efficacy, intrinsic value, anxiety and self-regulation strategies related to both computer use and science study used to discern changes in motivation over the course of the unit
Thermodynamics Science Content Surveys A and B (pre, post) influenced by similar surveys (Krajcik, Layman, Starr & Magnusson, 1991; Lewis, Stern & Linn, 1993, Lewis, 1994)	Measurement of student understanding of thermodynamics used to determine students' prior knowledge of thermodynamics, to discern changes in understanding over the course of the unit, and to triangulate students' thermodynamics understanding
Thermodynamics Project Pop Quiz developed for this study	Measurement of acquisition of student understanding of thermodynamics after doing the ELabBook simulations and experiment used to triangulate students' thermodynamics understanding

Data Source	Description
Thermodynamics Project Pop Quiz	Measurement of acquisition of student understanding of thermodynamics after doing the ELabBook simulations and experiment
developed for this study	used to triangulate students' thermodynamics understanding
Section and overall scores, including completeness and word count for ELabBook simulations and experiment	Measurement of student understanding of thermodynamics obtained through use of ELabBook, and motivation in and while using the software
developed for this study	used to discover the effect of student use of technology on science understanding and motivation
Insulating device temperature drop	Performance of culminating artifact for the unit
developed for this study	used to triangulate students' thermodynamics understanding
Group Contribution Survey	Report of final project design, role of the group and the computer in the creation of the final design
developed for this study	used to determine the effects of groupwork and other classroom characteristics that affect understanding

The connection between the four research questions and the above instruments will be explained, followed by a more detailed description of each instrument. The basic strategy used to address each research question is to triangulate multiple methods of measuring in order to converge on a justifiable answer to each question (Creswell, 2009).

### *Appraisal of Thermodynamics Understanding*

In this study, thermodynamics understanding is partly measured in a straightforward manner, similar to the way it is assessed in many classrooms at all levels of education: students took written exams, answered interview questions, or created artifacts. If the instruments are shown by the analysis throughout this chapter to be reliable indicators of understanding, then statistical comparisons of the data show whether or not understanding occurred. Such is the case

with instruments 3), 5) and 6) from Table 2, although one could argue a difference between a written and an oral assessment because they tap into different intelligences (Gardner, 2011). One can also posit that the test and interview assessments differ from an assessment based on the creation of an artifact, as the artifact is a concrete representation of the students' propositional knowledge that taps into a different grouping of skills, abilities and experiences than writing, as acknowledged by the second science learning strand of Michaels, Shouse & Schweingruber (2008), *generating scientific evidence*. This delineation of science practice has been a longstanding characteristic of the natural sciences expressed as a difference between the experimental and theoretical, which can also be expressed as a divergence of scientific study and expertise between validation by observation and validation by predictive power (AAAS, 1989). Thus even though instrument 8), the insulating device, measures thermodynamics understanding, it does so in a manner different from the other three instruments because it involves validation by observation, not just by prediction.

Some of this delineation can be seen in correlations among these variables, as shown in Table 3. The written assessments of *MEAP*, *PreTest*, *ELabBook*, *Pop Quiz*, and *PostTest*, were all very significantly correlated with each other. However, only the *ELabBook* score was significantly correlated with the change in temperature ( $\Delta T$ , where a smaller temperature drop indicates better performance of the insulating device). Note that  $\Delta T$ , the only outcome that was not in some sense a paper and pencil assessment, did not significantly correlate to the others. The effect sizes range from large, .50 to moderate, .30 (Cohen, 1992; Corder & Foreman, 2009).

Table 3

*Correlations between Measures of Thermodynamics Understanding*

Measure	MEAP	PreTest	ELabBook	Pop Quiz	$\Delta T$	PostTest
MEAP	1					
PreTest	.61***	1				
ELabBook	.54***	.53***	1			
Pop Quiz	.49***	.42***	.43***	1		
$\Delta T$	n.s.	n.s.	-.28*	n.s.	1	
PostTest	.58***	.56***	.59***	.43***	-.34**	1

Note: N ranges from 80 to 91 except for comparisons involving  $\Delta T$ , where it ranges from 65 to 72. Correlations of  $\pm .20$  or greater are significant at  $p < .05$ ;  $\pm .30$  or greater at  $p < .01$ ;  $\pm .40$  or greater at  $p < .001$

ELabBook has a unique nature in that it has built-in scaffolding of science content and scientific process within a sequence of modules that students complete during a simulation or investigation, such as *prediction, setup of axes, graph interpretation, understanding the main scientific principle, investigating research from other groups, and drawing a conclusion*. By measuring success on each of these modules, one may quantify the success students had with scaffolded learning of content and process, and see any correlation of that success with both the more traditional paper measures of understanding (content) and the insulating device (content and process). This is useful in addressing the research question, *What motivational or scaffolded learning aspects of the technology played the most important role in increasing understanding?* The mode of analysis follows a time-series scheme (Smith & Glass, 1987). In generic statistical analysis, correlations between variables do not imply causation, but in this time-series type design there is a chronology of when different measures of understanding were taken, which does allow causality to be suggested when there is a significant correlation between data and the time sequence warrants it. Of course, there is also another side to this question that deals with motivation, and the measures of motivation will be discussed subsequently. Creswell (2009) suggests that a phrase like *probable causation* is most appropriate for social science research

involving people in a natural context. Thus effects of probable cause rather than absolute cause are most likely to be claimed in this study.

The primary method of analysis for this question comes from the construction of two predictor models via multiple regression. Both predictor models are based on Figure 9, and may be characterized as follows: Prior Understanding + Motivation + Scaffolded Knowledge Growth = Science Understanding, with a check for effects from demographic variables. The independent variables are motivation, scaffolded learning, and race and gender; the dependent variable of thermodynamics understanding for the first model is measured by *PostTest*, and for the second model is measured by the temperature drop of the insulating device ( $\Delta T$ ). The nature of this question requires an answer to be causal and predictive, hence the use of regression models. Some insight into the previous discussion of theoretical and experimental science knowledge will be gained by comparing the predictors of the two models. Because there are a considerable number of data sources that correspond with the independent variables, a winnowing process is needed to seed each model. Winnowing is first based on correlations with the dependent variable; if there is no statistically significant correlation with either dependent variable, the measure was not analyzed in the model. The next stage of winnowing involves whether or not the independent variables were intercorrelated; measures of motivation or scaffolded learning that are correlated to the dependent variable but intercorrelated with other predictor variables of similar flavor, then only the independent variable with the highest correlation of that flavor is added to the model. The regression analysis then determines which of the seeded variables are significant contributors to the model.



The demographic variables that have been established as having the highest importance for this study are race and gender (the variables are referred to as *Race* and *Gender*), so the effects of these variables on the model are also examined. A third variable related to the course section or class (*Class*) is also checked because it was noted in chapter three that there was a dynamic unique to each of the classes that may have also impacted academic performance. An example of such a class effect may be seen in Figure 10, which compares five measures of thermodynamics understanding each normalized to their own population average, showing the percentage deviation from the norm for each sample: 0% indicates the average.

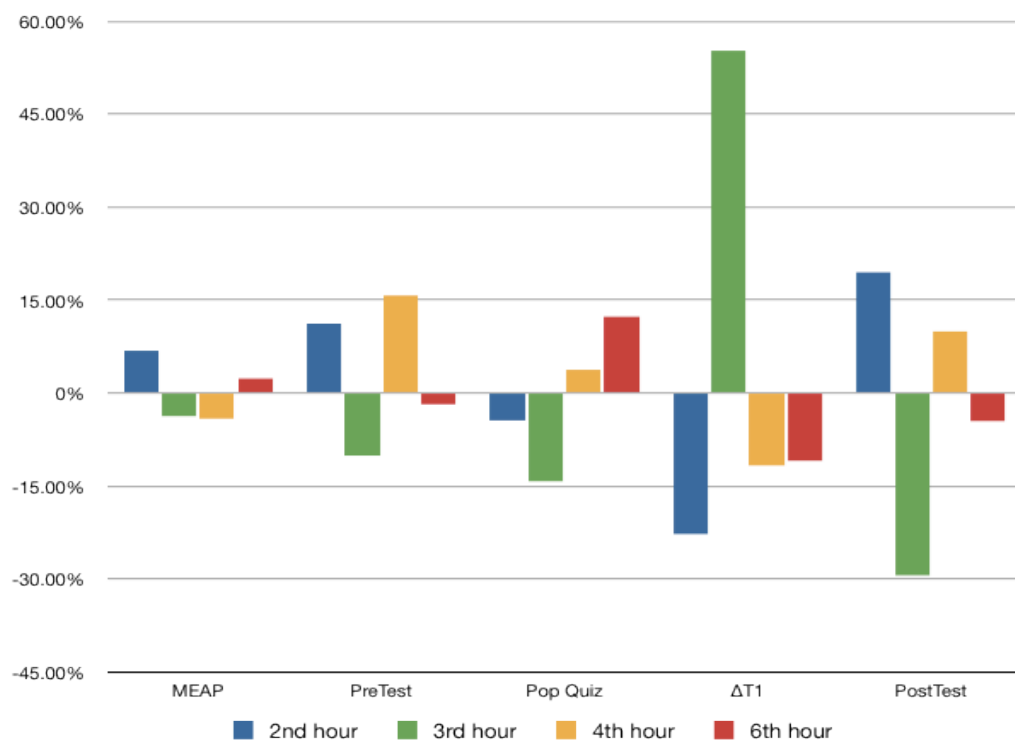


Figure 10: Portrayal of class effect on different measures of understanding.

In each case, the 3<sup>rd</sup> hour class lags behind the others. Both the 3<sup>rd</sup> and 4<sup>th</sup> hour class have similar average scores for MEAP, suggesting a similar starting point for prior knowledge.

However, the 4<sup>th</sup> hour class outperforms 3<sup>rd</sup> hour in all the other measures. Note that for  $\Delta T_I$ , the initial attempt at an insulating device, a negative score indicates a smaller drop and thus a more efficacious design. The reliability and validity study for *PreTest* and *PostTest* later in this chapter will address this issue of the 3<sup>rd</sup> hour class.

Two of the other questions listed at the beginning of this chapter involve an appraisal of thermodynamic understanding: *Did student understanding of thermodynamics increase, given this particular classroom environment and high effort in the use of technology?* and *What were the interactions of race and gender upon content understanding?* Both are addressed through appraisal of thermodynamics understanding across the span of the unit, based on the thermodynamics content surveys and interviews that are both administered before and after the unit, with checks for the influence of demographic variables. This mode of analysis follows that of a one-group, test-retest design (Campbell & Stanley, 1963).

One method of appraisal is through paired repeated measures comparison of both the overall scores on the content surveys (*PreTest*, *PostTest*, and the difference between the two,  $\Delta Test$ ), and the paired itemwise scores for the surveys, such as comparing the score on item 1 of *PreTest* with item 1 of *PostTest*. The nine items on the surveys correspond to the three principal unit subquestions identified in chapter three, “what is heat?, how does heat behave?, and how do you measure heat?” If both types of comparisons show an improvement in science understanding, the case for finding an affirmative answer to the question is strengthened as itemwise increases show increased understanding across the spectrum of thermodynamics content studied during the unit. The effects of *Race*, *Gender*, and *Class* will also be assessed.

Another method of appraisal is a similar repeated measures analysis of the two questions in the interviews (*PreInterview*, *PostInterview*) that pertain to thermodynamics understanding. One of the questions was identical to one of the items on the content survey, and the other question was identical to one of the sections of the ELabBook simulations. As noted in chapter three, a smaller subset of the population was asked to participate in the interviews. In this case, the student responses to the interview questions are categorized and compared to determine if there was movement towards categories indicating stronger thermodynamics understanding. Interestingly, there was no significant correlation between the interview question scores and any of the other measures of understanding with the exception of *PreTest* and the interview question identical to one of the *PreTest* items. This could evidence the difference between written and oral assessment hinted at earlier. Because the interview results may uncover a different aspect of understanding from the other measures, they are included in the triangulation strategy to assess understanding. No demographic analysis on *PreInterview* or *PostInterview* was done because of the much smaller sample size, especially when broken down by demographic groupings.

#### *Appraisal of Motivation*

The two questions, *What motivational or scaffolded learning aspects of the technology played the most important role in increasing understanding?* and *Was the use of technology more academically motivating to the students?* require an appraisal of motivation that will allow specific motivational constructs to be pinpointed. In contrast to the measurement of thermodynamics understanding, the measurement of motivation undergirded by a philosophy of triangulation of data means that there will be several variables corresponding to instruments that

feed much information about the subjects, so it will be important to be able to filter the information to find the “nuggets” and do the pinpointing. The mode of analysis is again a combination of a one-group test-retest design for the predictor models and a time-sequence scheme for the breakdown of the motivation inspired by the technology. The motivational constructs being measured correspond to the basic psychological needs of at-risk students (and by application of Universal Design-type thinking, to all students) identified in chapter two: feelings of competence, usefulness, optimism, belonging, and potency. In chapter two, these constructs were aligned with concepts more commonly used in motivational research when a match was possible; for example, a feeling of competence was associated with self-efficacy, a feeling of usefulness with intrinsic value, etc. One of the reasons for making these associations was to allow a well-established tool for measuring well-understood motivational concepts, the Modified Strategies for Learning Questionnaire or MSLQ, to be modified very slightly and used in this study. The modified MSLQ (*mMSLQ*) does not measure anything associated with a feeling of belonging or potency, so other measures are required for those constructs.

Returning to the list of data sources contained in Table 2, the instruments that will be used to measure these motivational constructs include the attendance (1), the mMSLQ (4), and completeness, or whether or not students completed ELabBook simulations and experiments or built an insulating device, and how many words they entered into the software each time they used it. These data sources correspond to the five constructs and their more familiar counterparts as shown in Table 4.

Table 4

*Motivation Associations and Data Sources*

Construct	More Common Concept (if applicable)	Data Source
Competence	Self-Efficacy	<ul style="list-style-type: none"> <li>mMSLQ Self-Efficacy subscale, for each of science learning and computer use (<i>Science Self-Efficacy Pre, Science Self-Efficacy Post, Computer Self-Efficacy Pre, Computer Self-Efficacy Post</i>)</li> </ul>
Usefulness	Intrinsic Value	<ul style="list-style-type: none"> <li>mMSLQ Intrinsic Value subscale, for each of science learning and computer use (<i>Science Intrinsic Value Pre, Science Intrinsic Value Post, Computer Intrinsic Value Pre, Computer Intrinsic Value Post</i>)</li> </ul>
Optimism	Anxiety Self-Regulation	<ul style="list-style-type: none"> <li>mMSLQ Anxiety subscale, for each of science learning and computer use, and mMSLQ Self-Regulation subscale (<i>Science Anxiety Pre, Science Anxiety Post, Computer Anxiety Pre, Computer Anxiety Post, Self-Regulation Pre, Self-Regulation Post</i>)</li> </ul>
Belonging	not applicable	<ul style="list-style-type: none"> <li>Attendance prior to the unit (<i>Attendance Pre</i>)</li> <li>Attendance during the unit (<i>Attendance Project</i>)</li> <li>Attendance during the time ELabBook was used (<i>Attendance ELabBook</i>)</li> </ul>
Potency	not applicable	<ul style="list-style-type: none"> <li>Whether or not ELabBook reports were completed (<i>Completeness ELabBook</i>)</li> <li>Whether or not the pop quiz was completed (<i>Completeness Pop Quiz</i>)</li> <li>Whether or not construction and testing of an insulating device was completed (<i>Completeness <math>\Delta T</math></i>)</li> <li>Word Count when completing ELabBook reports (<i>Word Count</i>)</li> </ul>

If these variables all measure motivation, it would stand to reason that they would have some correlation with each other – that they together provide a greater measure of motivation even as they individually represent different aspects of that greater.

Table 5 shows how well correlated the motivational measures were prior to the start of the project. Since the mMSLQ has some standing as a measure of motivation, the question is whether the other measures of attendance and completeness also belong.

Table 5

*Comparisons of Student Attendance with Other Motivation Variables  
Pre-Project*

	1	2	3	4	5	6	7	8
1 Science Self-Efficacy Pre	1							
2 Science Intrinsic Value Pre	.75	1						
3 Science Anxiety Pre	-.31	n.s.	1					
4 Computer Self-Efficacy Pre	.72	.62	-.21	1				
5 Computer Intrinsic Value Pre	.73	.77	-.21	.74	1			
6 Computer Anxiety Pre	n.s.	n.s.	.45	-.40	n.s.	1		
7 Self-Regulation Pre	.68	.73	-.24	-.53	-.71	n.s.	1	
8 Attendance Pre	-.47	.23	.30	-.45	-.40	.27	-.22	1
9 Completeness Science Fair	.25	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-.23

Note: N ranges from 88 to 96; Correlations of  $\pm .21$  or greater are significant at  $p < .05$ ;  $\pm .29$  or greater at  $p < .01$ ;  $\pm .36$  or greater at  $p < .001$

*Attendance Pre* was significantly correlated with every one of the other pre-project motivation measures. With the mMSLQ, higher scores indicate a greater presence of the construct, e.g. higher self-efficacy, higher intrinsic value, more self-regulation, and more anxiety. A higher score for completeness on the science fair indicates that the student submitted a

project. The effect sizes would be mostly in the range of moderate, .30 - .50 (Cohen, 1992; Corder & Foreman, 2009), which suggests that *Attendance Pre* and the other variables are not interchangeable but do measure a similar construct, which is motivation. One would expect that students who were less inclined to attend class would also feel less competent, less useful, less optimistic, and less potent. The nature of the relationship of each correlation was what one would expect: *Attendance Pre* was proportional to anxiety, and inversely proportional to the other variables. This finding gives some justification for the use of attendance as a measure of motivation. By contrast, *Completeness Science Fair* only had significant correlations with attendance and science self-efficacy. Some more study is needed to see if completeness is a reasonable motivational measure, as carried out below.

One of the reasons for appraising motivation is to determine which (if any) motivational constructs fit into the basic model – to determine predictors of knowledge gain. As noted in chapter two, there is some crosstalk between motivation and the degree of learning. If measures of prior understanding are correlated to *Completeness Science Fair*, then it provides the researcher with more comfort about the use of completeness as a measure of a motivational feeling of potency. The logical indicators of prior knowledge are the two pre-project measures of understanding, *MEAP* and *PreTest*. The value of including *MEAP* is that it is a validated instrument (by the State of Michigan) that can stand in as a measure of prior knowledge alongside *PreTest*. *MEAP* and *PreTest* are also strongly correlated,  $r(84) = .61$ ,  $p < .001$ . And in fact, both measures are significantly related to completeness;  $r(87) = .24$ ,  $p < .05$  and  $r(88) = .27$ ,  $p = .01$ , respectively. Anxiety in both science and computer domains prior to the project were also significantly associated with *MEAP* and *PreTest*. This circuitous tie between completeness

and motivation provides the researcher with added comfort about the use of completeness as a motivational indicator, but more triangulation would be helpful and is forthcoming.

It is also worthwhile to make a similar comparison of the motivational variables after the conclusion of the project, to double-check on how well the group works together to measure motivation. The greater the correlation, the more likely they are measuring a similar construct. This time, attendance during the project and the ELabBook lab time, the word count for ELabBook, and completeness of the insulating device are standing in for the constructs of belonging and potency. This comparison is shown in Table 6.

A glance at Table 6 shows groups of intercorrelation with large effect sizes within the group and moderate or small effect sizes outside the group: the groups seem to consist of 1) attendance, 2) completeness, 3) self-efficacy, intrinsic value and self-regulation, and 4) anxiety and self-efficacy. It also shows that *Word Count ELabBook* was significantly correlated with the greatest number of other motivational variables, followed by *Science Self-Efficacy Post*, *Attendance Project*, and the mMSLQ subscales. The measures that had the fewest number of correlations were *Completeness  $\Delta T$* , *Completeness ELabBook*, and *Attendance ELabBook* but the two completeness scores did each have correspondence with science self-efficacy. There is also a correlation between *Completeness  $\Delta T$*  and *Word Count ELabBook*, which is noteworthy because both measures are intended to gauge feelings of potency at the end of the project. The strength of the word count measure suggests its inclusion as a motivational measure, while the poor performance of *Completeness ELabBook* probably excludes it. Percentage of completed work seems like it should be an indicator of the students' belief that he/she is capable of acting upon



the school work until they have completed it, but a better case for the use of completeness awaits yet another set of calculations.

Table 6

*Comparisons of Student Attendance with Other Motivation Variables, Post-Project*

	1	2	3	4	5	6	7	8	9	10	11
1 Attendance Project	1										
2 Attendance ELabBook	.86	1									
3 Completeness ELabBook	n.s.	n.s.	1								
4 Completeness $\Delta T$	.38	-.23	.51	1							
5 Word Count ELabBook	.29	-.22	.76	.46	1						
6 Science Self-Efficacy Post	-.22	n.s.	.29	.24	.31	1					
7 Science Intrinsic Value Post	n.s.	n.s.	n.s.	n.s.	.25	.75	1				
8 Science Anxiety Post	.22	n.s.	n.s.	n.s.	-.23	-.36	n.s.	1			
9 Computer Self-Efficacy Post	-.22	n.s.	n.s.	n.s.	.29	.79	.73	-.24	1		
10 Computer Intrinsic Value Post	n.s.	n.s.	n.s.	n.s.	.24	.65	.76	n.s.	.79	1	
11 Computer Anxiety Post	n.s.	n.s.	n.s.	n.s.	-.33	-.45	-.22	.57	-.54	-.30	1
12 Self-Regulation Post	-.21	n.s.	n.s.	n.s.	n.s.	.67	.63	-.23	.64	.71	-.29

Note: N ranges from 88 to 99; Correlations of  $\pm .21$  or greater are significant at  $p < .05$ ;  $\pm .29$  or greater at  $p < .01$ ;  $\pm .36$  or greater at  $p < .001$

The large number of variables and intercorrelations in Tables 5 and 6 suggests that analysis of motivation in a predictor model may prove to be unwieldy if all of the variables are involved in the calculation. Furthermore, the justification for the use of variables measuring completeness has not been fully supported; however, the appearance of groups of variables

intercorrelated with large or moderate effect size suggests the existence of a smaller number of groups or factors among all these motivation variables. A principal components analysis would help with both uncertainties; if the data from these instruments can be loaded onto a smaller number of factors, then predictor analysis will be more nimble. If the factors correspond to the five motivational constructs, it will more definitively reveal which data sources should be used to appraise motivation. If variables representing completeness significantly load onto a factor with some contribution from one or more other measures, it would provide just enough of a rationale to continue to use completeness as a measure of potency.

In order to determine how well individual or grouped motivation variables represent the five feelings articulated in chapter two, a principal components analysis was performed to see if the post-project variables loaded onto components that aligned with the feelings. A direct oblimin rotation with Kaiser normalization was employed, and components whose eigenvalue was 1 or greater were retained. The value of KMO was .724 and Bartlett's test was significant, which indicates an appropriate data set for principal components analysis. Four components had eigenvalues greater than 1, accounting for 81.8% of the variance.

The motivational constructs and measures loaded onto four rotated components as shown in Table 7.

Table 7

*Summary of Principal Components Analysis for Motivation Variables, Post-Project*

Construct and Measures	Component 1	Component 2	Component 3	Component 4
Competence				
<i>Self-Efficacy</i>	S: .855 C: .890		S: -.443 C: -.413	C: .288
Usefulness				
<i>Intrinsic Value</i>	S: .883 C: .918			
Optimism				
<i>Anxiety</i>			S: .883 C: .879	
<i>Self-Regulation</i>	.827			
Belonging				
<i>Attendance Project</i>		.962		
<i>Attendance ELabBook</i>		.964		
Potency				
<i>Completeness <math>\Delta T</math></i>				.880
<i>Word Count ELabBook</i>	.260		-.360	.809

Note: "S" represents the mMSLQ scale for science, "C" for computers.

Variables pertaining to self-efficacy, intrinsic value, and self-regulation loaded most strongly onto the first component with weaker contributions from computer anxiety and word count. This suggests that feelings of competence and usefulness are more closely aligned, along with self-regulation. The second component reflects feelings of belonging very cleanly. Sagor (2004) notes that attendance problems are often a hallmark of the at-risk student, thus the students who are positively motivated by what they are doing in class will attend more often. In this classroom, the time spent in the computer lab is contiguous and known in advance, so students who wish to "ditch class" or intentionally be absent would know exactly when to do so. The third component has stronger contributions from anxiety, and lesser ones from self-efficacy

and word count; this third component is probably best allied with feelings of optimism. The fourth component had strong contributions from potency, and a weak contribution from computer self-efficacy, and likely represents feelings of potency.

The split between anxiety and self-regulation suggests that feelings of optimism may be best represented only by measures of anxiety, and that self-regulation stands by itself but in league with self-efficacy and intrinsic value. The results of this principal components analysis will be used again when it comes time to generate a predictor model for  $\Delta T$  and *PostTest* scores, to see if these four components of motivational measures have more predictive power than the five feelings or the eleven individual variables.

The full suite of variables will be more useful when considering the question of whether the use of technology was more academically motivating to the students, because they are better able to discriminate effects; for example, the mMSLQ subscales can discern between computer effects and science learning effects. The effect of each construct will be analyzed in turn, utilizing a time sequence design. There will be a check of intercorrelations to determine whether the data reflects a stable representation of the construct; if this is the case, then the paired mean difference will be checked for changes over time and the domains of learning science and computer use. When the changes can be logically ascribed to the use of technology, they will be highlighted.

Additional data regarding the features of scaffolded learning and motivation from the technology that helped the students learn the content will come from a couple of other sources.

The Group Contribution Survey (*Group Contribution Survey*) includes questions that ask the students to attribute the most helpful source of information in designing their insulating device. This information can be tabulated as well as correlated with the performance of their insulating device to shed more light on the motivational influence of the technology. In the *PostInterview*, one of the questions specifically asks the students to identify characteristics of the technology that they felt were motivating or demotivating. Their perceptions will facilitate more careful triangulation on the most helpful characteristics of the technology.

## **Instruments**

The design, function, and reliability of the each of instruments are discussed below. The instruments themselves are included in Appendix A.

### *Demographics*

The classroom demographic data consisted of each students' gender, race, daily attendance throughout the year, quarterly and semester grades, standardized science test score (MEAP), and a grade for a major class report that was given prior to the beginning of the unit. The data was provided either by the school administration or by the teacher on the basis of the professional development school relationship in effect at that time.

Gender and race data was provided by the school administration (*Gender, Race*). Both gender and race were scored as dichotomous variables; students are classified as either male or

female, and as either white or black. There were no other races represented in the four classes of eighth grade students during that academic year, and the school did not record the Latino ethnicity of its students so the only racial comparison possible is between black and white students. This researcher's perception of the Latino population in the four classes is that it was scant.

Accessibility of the daily attendance records for each student allowed the attendance data for this study to be reduced to three categories of percentages that allow for ready comparison: the percentage of days the student was absent from class from the beginning of the year to the day before the unit started (*Attendance Pre*), the percentage of days the student was absent from the first to the last day of the unit (*Attendance Project*), and the percentage of days the student was absent during the interval when the ELabBook simulations and experiment were to be performed (*Attendance ELabBook*). The total numbers of days in each block are 104, 44, and 15 respectively. Excused absences were not counted for or against a student, so the maximum possible number of attendance days varies slightly by student, which is why the data were represented as percentages.

All quarterly and semester letter grades for each student enrolled in a science class section with the teacher were made available (*Semester Grade*). The grades were translated from letters to numbers, employing a scoring system where A = 4.0, A- = 3.70, B+ = 3.30, etc. The grade for a major class report, a science fair project that took place prior to the unit, was also provided and similarly translated. From this science project grade, a dichotomous completion score was calculated (*Completeness Science Fair*).

The standardized science test scores (*MEAP*) for the students were obtained from the school administration, and were used with no change.

The validity of demographic data is more or less assumed, subject to common sense applied throughout the course of the project, for example that a student's gender or race appeared correct, that an attendance record for each day was received, etc.

#### *Student Background for Computer Use and Science-Related Activities*

This is a multiple choice/short answer survey designed to characterize the students' interest in science and computer use outside of the classroom. It was administered prior to the start of the project, and is divided into three parts. The first section asks the student if their family owns a personal computer and if so, the type. This data is intended to show whether the student has access to a computer at home, and how knowledgeable they are on a base level about the type of computer owned. The students are also asked if they ever use computers outside of class; if they answer "no", then they skip to the third section.

The second section is designed to characterize the students' out-of-school computer use. The students are asked where they use a computer and how often. It allows each student to describe the type and location of computer most used, amount of usage, type of usage (software application), whether usage is collaborative or individual, and whether the student has taken a computer class at the school. This establishes a profile of the student's "preferred" computing style, whether to work alone or with others and what sorts of applications are preferred. This

portion of the survey addresses the question of whether the students are familiar enough about computers so that their interest in them is not easily influenced by novelty.

The final section of the survey is similar to the second, but directed towards the students' science experience. The students are asked who their previous middle school science teachers are, whether they had entered the science fair in the past three years, and why. They also report on whether they have experienced either formal (camps, special classes) or informal training (hobbies, family field trips) in science, and their plans for taking science classes in high school.

The survey was mainly meant to provide the researcher with some background information on a student population with whom he was not already familiar. But one interesting bit of data was discovered. Of the 91 students who were surveyed with this instrument, 42% lived in a household that owned a computer, and 81% either had a computer at home or had taken or were taking a computer class in school. This compares to a recent report by the government (Department of Commerce, 2011) that showed that 37% of American households owned a computer in 1997 (two years after the above data was gathered), and that 77% of households now own a computer or mobile device, increasing to 86% in households with school-aged children. With respect to class effects, only 50% of the students in 3<sup>rd</sup> hour either had a computer at home or a computer class at school, far lower than any of the other classes (2<sup>nd</sup> hour, 75%; 4<sup>th</sup> hour, 84%; 6<sup>th</sup> hour 82%). Familiarity with the computer may have been a unique issue for this particular group.



The self-reported computer experience of these students was commensurate with the mainstream of the nation at that time, which speaks to the validity of the information. However, none of the data from this survey is used in this study because it was truly intended only as a source of anecdotal background information.

### *Modified MSLQ (mMSLQ)*

In its original form, the MSLQ (Motivated Strategies for Learning Questionnaire) is a self-report, Likert survey administered in a generic classroom setting over approximately 30 minutes (Pintrich & de Groot, 1990). It was developed in order to assess the motivational orientations of students as well as their use of learning strategies; the original version was used with middle school students, and a subsequent version for college students. For an assessment of motivation, sets of items from the MSLQ are grouped together to form measurement subscales that measure the specific constructs of self-efficacy, intrinsic value, test anxiety, learning strategies, and self-regulation. The MSLQ was designed so that one or more sets of items corresponding to each subscale can be used independently or in any combination to measure the corresponding constructs. Pintrich, et al. (1993) examined the reliability and predictive validity of the college-aged version of the instrument and reported a positive finding. Garcia and Pintrich (1995) subsequently connect the positive reliability and predictive validity of both the middle-school and college-aged versions.

A modified version of the middle school version of the MSLQ, called the mMSLQ in this thesis, is used to gauge changes in student motivation towards both science learning and the use of computers. Pintrich suggested that greater specificity in the wording of the items would allow

the survey to measure motivation towards either subject (P. R. Pintrich, personal communication, October 13, 1994) without disturbing the reliability. Specificity meant that more generic classroom terms in the wording of the items was replaced with wording more specific to learning science and with the use of computers. An example of this specificity would be the following:

*MSLQ* – “I prefer class work that is challenging so I can learn new things.”

*mMSLQ* – “I prefer science class work that is challenging so I can learn new things,” or  
“I prefer computer work that is challenging so I can learn new things.”

The original item appears in the self-efficacy scale; the first rephrased item is in the science self-efficacy scale, and the second one used for computer self-efficacy.

The items and subscales of the *mMSLQ* were chosen to help determine student motivation towards the domains of computer use and learning science in class for the motivational constructs of self-efficacy, intrinsic value, anxiety, and self-regulation because they had some association with the five feelings of belonging. The wording of items on the self-regulation subscale did not lend that scale to being directed towards science or computers because it would take more than the modification of a noun, and the validity and reliability already established by Garcia and Pintrich (1995) would be placed in jeopardy; thus that subscale was not altered.

It also did not make sense to use the *MSLQ* items related to learning strategies because the language of those items were geared towards a traditional classroom curriculum with a

textbook, chapter questions, and vocabulary lists; thus that subscale was omitted from the mMSLQ.

The mMSLQ was administered at two times, once before and once after the project. Scale results were determined by summing the responses for each construct. A comparison of the results between the administrations of the mMSLQ will help show whether any change occurred, presumably change as a result of involvement with the technology and the science of the project. Since some of the constructs, notably self-efficacy, are slow to change it is possible that the instrument will not record a significant change in motivation towards science and technology on a population or class averaged basis. However, it is expected to help point out correlations with motivation and gender, ethnicity, attendance, MEAP score, artifact assessment, science content surveys, interview data, and other variables. The presence or absence of such correlations is the basis in this study for indicating when a student appears motivated or unmotivated. For example, *Self-Efficacy Pre* was significantly correlated with *Science Fair Grade*,  $r(86) = .23$ ,  $p < .05$ , but not with either *MEAP* or *PreTest*. The science fair stands in as a representation of experimental science knowledge prior to the unit, while either *MEAP* or *PreTest* fulfills the same role for theoretical knowledge. This result is representative of some of the data from chapter one, where American students tend to be more mismatched in this regard than students from other countries. In chapter five, this relationship will be examined again for change.

The mMSLQ used in this study is presented in Appendix A.

### *Thermodynamics Science Content Surveys*

These surveys are content tests consisting of nine groups of multiple choice and short answer questions administered to the students during a single class period. Each group consists of anywhere from two to four items that question the student about a case or scenario. The maximum possible score on the surveys is 90. The surveys are used to gauge changes in student understanding of the thermodynamics concepts discussed in this project, and were constructed specifically for this study. Most of the items were taken directly from similar assessments utilized in previous contexts with thermodynamics and MBL (Layman & Krajcik, 1988; Lewis, 1991; Clark and Linn, 2003), and the others had a similar etymology and style to those items. The classroom teacher, a professor of science education, a graduate research assistant from the CLP project, and a graduate research assistant who also served as a second rater critiqued the surveys. The surveys draw content validity from those examinations. The surveys are introduced to the students as exams, where it is emphasized that the improvement in score from one to the other is esteemed above the absolute score of each. The grouped items of the surveys are associated with the three major sub-questions articulated in chapter three: “what is heat?” “how does heat behave?” and “how do you measure heat?”

The items are written in the form of simple scenarios or cases in order to suggest and demonstrate to the students the importance of applying their knowledge to cases (Schank & Cleary, 1995). In taking the survey before the project began, the students are provided with a context for all of the knowledge they may potentially acquire throughout the project. Each item has a multi-response format. The initial query elicits a proper application of knowledge of a concept, and subsequent queries allow the student to either describe the rationale employed in

providing the initial response or to elaborate a deeper understanding of the concept. As noted in previous chapters, the target thermodynamics knowledge is based upon the CLP model of macroscopic heat flow to allow for consistency with ELabBook's simulations and scaffolded learning environment, rather than the kinetic theory of heat transfer. The score of all the items within a group are added together to create a subtotal for each of the nine groups, whose scores are then added together to produce a total score. A breakdown of grouped items by concepts and knowledge is shown in Table 8.

Table 8

*Delineation of Science Content on Surveys*

Group	Related Sub-question	Concept	Requisite Knowledge
1	"What is heat?"	Energy Conservation	Energy is conserved as it changes from different forms to heat
2	"How does heat behave?"	Insulators and Conductors	a material works equally well to keep hot things hot as to keep cold things cold
3	"How do you measure heat?"	Temperature scales	temperature is a measure of the amount of heat energy in a material
4	"How do you measure heat?"	Measuring devices, Calibration	a thermometer may be used when it has been calibrated for the temperature range of interest
5	"How does heat behave?"	The second law of thermodynamics	the temperature of all objects in a closed room (assuming none are heat sources) will come to equilibrium
6	"How does heat behave?"	The second law of thermodynamics	a larger surface area and a smaller volume will result in higher heat transfer rates
7	"How does heat behave?"	The second law of thermodynamics	heat energy flows continuously from the warmer body to the cooler
8	"What is heat?"	Macroscopic model of heat flow	heat flows within and through different materials at different rates
9	"How do you measure heat?"	Using ELabBook, Using MacTemp	graphical interpolation

Each item or question listed in Table 8 has two different versions, one for survey A and for survey B. Each group of item questions also has two formats. In one format the initial query has a theoretical approach and resulting queries proceed to the experiential, while in the other the opposite holds. The two types of formats were then assigned to the surveys so that each would have a 4/5 or 5/4 split between them. Survey A had a total of 25 items, and survey B had 26. Both of the surveys are included in Appendix A.

Since it is not known for certain whether the cognitive demands of the two surveys are comparable, the surveys are administered in a counterbalanced manner. At the start of the unit, Survey A was administered to 3<sup>rd</sup> and 6<sup>th</sup> hours, and Survey B to 2<sup>nd</sup> and 4<sup>th</sup> hours; at the end of the unit, A was given to 2<sup>nd</sup> and 4<sup>th</sup> hours, and B to 3<sup>rd</sup> and 6<sup>th</sup>. A study of the reliability of the surveys stems in part from checking whether the rubric can be evenly applied by knowledgeable raters and in part from determining whether or not one is significantly "harder" than the other.

The surveys are scored according to a prescribed rubric, which is also included in Appendix A. The items are assessed according to how well what is written agrees with common scientific understanding of the thermodynamics concepts involved, as judged by the researcher. The rubric is constructed after an initial pass has been made to gauge the spectrum of student responses, so that both full and partial credit may be given. In order to ascertain whether the rubric could be evenly applied by anyone with science background, an interrater comparison project was undertaken.

A second rater used the rubric to rate the surveys from a subgroup of the sample population. The subgroup was chosen by randomly selecting one of the four classes, and then randomly selecting half of the pretest surveys and half of the posttest surveys. This second rater was a graduate student in a science education doctoral program who is a degreed engineer, with educational experience as a science tutor for middle and high school students. The rater had no knowledge of the sample population, or of the fact that he/she was rating surveys administered at different times. A plot of the inter-rater correlation between the researcher and the second rater for both pretest surveys is shown in Figure 11.

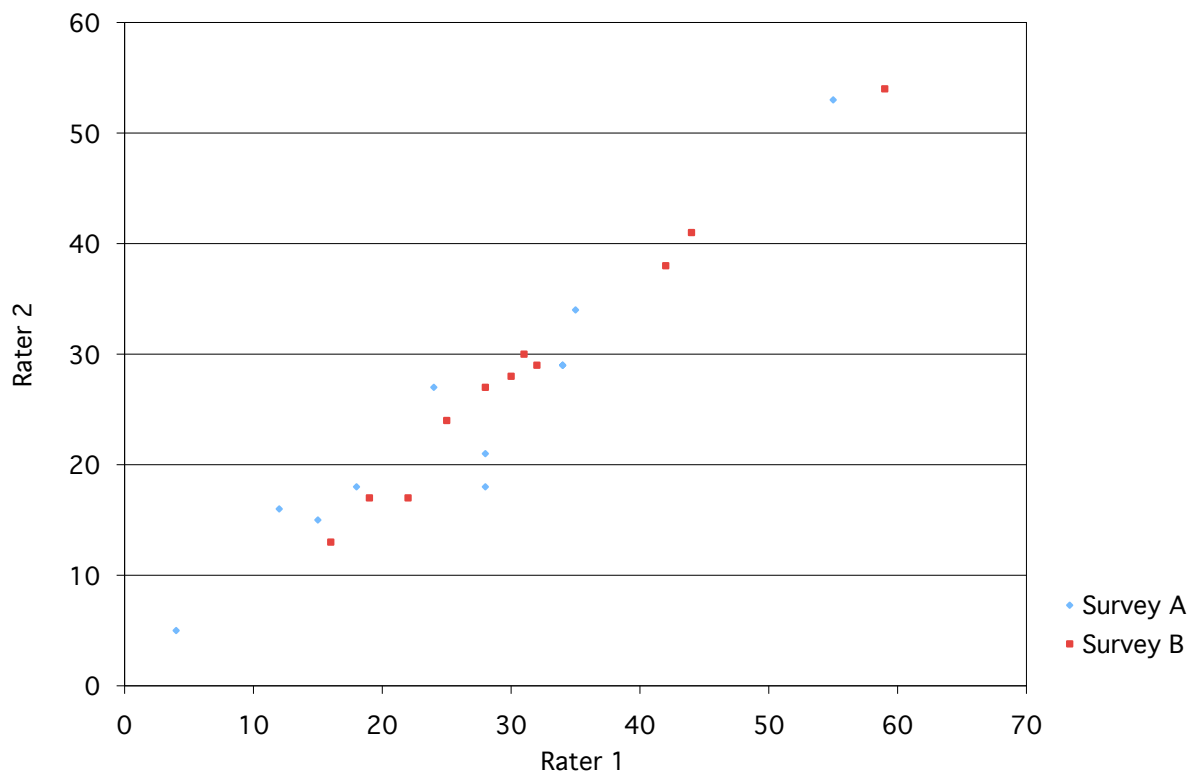


Figure 11: Inter-rater correlation for content survey at Pretest.

The overall correlation coefficient,  $r$ , for the content surveys is .972; .952 for the “A” survey and .994 for the “B” survey. Based on this data, a high degree of reliability is assumed for the scoring of the content surveys by one person, the researcher.

The reliability of the surveys was assessed in two different ways. First the reliability of each survey was determined separately utilizing all 25 or 26 items. For the 25 items on survey A with  $N=45$  on the *PreTest*, Cronbach’s alpha is .81. This indicates a minimally acceptable reliability for the survey. The weakest grouping of items on survey A was eight, which asked the student to provide examples of objects that are good conductors or insulators, and why. This group of items is very similar to what was used in the CLP curriculum to assess student understanding of macroscopic flow, and is an area targeted for knowledge growth through ELabBook. For the 26 items on survey B with  $N=47$  on the *PreTest*, Cronbach’s alpha was .74. As a second check, for the *PostTest* with  $N=42$ , Cronbach’s alpha was slightly higher at .78. This is a modest reliability score that suggests the survey could be improved before being utilized in future research, but can be considered minimally acceptable for this study (Lance, Butts and Michels, 2006).

The weakest items on survey B include one that asks the students to explain what an object that keeps hot things hot would also keep cold things cold, and one that asks the students to discern whether objects at the same temperature have the same heat energy. The first item is a CLP targeted concept and one of the key points of knowledge for constructing the insulating device, while the second one was developed specifically for this project. In the *PostTest*, the first item was still weak, but not the second one; instead, items relating color and heat



absorption/reflection were weaker, and those items were developed locally. Interestingly, Cronbach's alpha was also higher for survey A on the PostTest (.82), which implies that stronger content knowledge among the students can slightly improve the reliability of the instrument that measures that content knowledge.

The reliability for using both surveys together was determined using a split-half analysis between both surveys based on the nine groups for the *PreTest*. The nine items for survey B formed the top half, and the nine for survey A the bottom half, and listwise deletion of cases was utilized so that N=81. The Spearman-Brown coefficient is .68, Cronbach's alpha is .61 for the top half (B) and .79 for the bottom half (A), and the correlation between the surveys is .51. The overall value of alpha is .81. Survey B has a correlation ( $r^2$ ) of .61 with the results of a state standardized science test, and Survey A has a correlation of .55. These results seem to indicate an adequate degree of reliability, sufficient to justify claims from this study.

Table 9 shows correlations between similar items on surveys A and B for the *PreTest*.

Table 9

*Intergroup Content Survey Correlations*

Group	$r^2$
Energy Conservation	.290
Insulators and Conductors	.207
Temperature scales	-.078
Measuring devices, Calibration	.313
The second law of thermodynamics (equilibration)	.205
The second law of thermodynamics (surface and volume effects)	.291
The second law of thermodynamics (direction of heat flow)	.138
Macroscopic model of heat flow	.145
Using ELabBook, Using MacTemp (graphing)	.323

The only negative correlation is between the group of items covering temperature scales between surveys A and B. This suggests that results from that group could be eliminated from subsequent analysis of both surveys. However, if there were an overall improvement in score from *PreTest* to *PostTest* on the temperature scale group (which turns out to be the case in chapter five), discarding this result would be to discard a measure of thermodynamics understanding, which would be philosophically undesirable. One important thing to remember is that every piece of knowledge tested on the surveys was addressed directly in at least one class session or simulation/experiment, and the underlying concepts of this knowledge, such as the second law of thermodynamics and both the macroscopic and kinetic models of heat transfer were addressed multiple times. Content validity for the surveys comes from this, but in order to assess the measurement validity, performance on both pretest and posttest should be examined with some additional weight placed on the posttest scores because the students would have had a chance to learn the content before being measured.

In order to triangulate more data and analysis on the issue of validity, classic test theory was also applied where levels of difficulty and discrimination were calculated for each of the multiple choice items on both survey A and B for *PreTest* and *PostTest*. Most item analysis of this type is done on multiple choice tests where the answer is either awarded full credit or not, rather than open-ended ones with partial credit available (Legg, 1991; Wollack, 2005; Michigan State University, 2009; Florida State University, 2011). Eight of the nine groups of items listed in Table 9 start off with a multiple choice item, which is followed up by open-ended items; group nine did not have a multiple choice item. The idea is that since the multiple choice item guided the students through the rest of the items for that group, a classic test analysis can be used to

evaluate validity. The results are shown in Table 10, along with the average score on each survey for students who took both pretest and posttest (N=81; 2<sup>nd</sup> hour had 19, 3<sup>rd</sup> hour 14, 4<sup>th</sup> hour 24, 6<sup>th</sup> hour 24).

Table 10

*Indices of Difficulty and Discrimination for Multiple Choice Items on Content Surveys*

Groups	1	2	3	4	5	6	7	8	9	Average
<b>Difficulty</b>										
PreTest A (3 <sup>rd</sup> /6 <sup>th</sup> )	0.64	0.19	-	0.51	0.04	-	0.24	-	-	22.6
PreTest B (2 <sup>nd</sup> /4 <sup>th</sup> )	-	0.63	0.14	-	0.48	0.43	0.47	0.54	-	27.2
PostTest A (2 <sup>nd</sup> /4 <sup>th</sup> )	0.76	0.35	-	0.70	0.23	-	0.50	-	-	38.0
PostTest B (3 <sup>rd</sup> /6 <sup>th</sup> )	-	0.69	0.16	-	0.53	0.60	0.50	0.64	-	28.6
<b>Discrimination</b>										
PreTest A	0.64	0.27	-	0.75	0.17	-	0.25	-	-	22.6
PreTest B	-	0.27	0.05	-	0.46	0.48	0.35	0.82	-	27.2
PostTest A	0.61	0.21	-	0.75	0.5	-	0.42	-	-	38.0
PostTest B	-	0.15	0.4	-	0.5	0.48	0.35	0.30	-	28.6

Note: The groups correspond to those listed in Table 9: (1) Energy conservation, (2) Insulators and conductors, (3) Temperature scales, (4) Measuring devices, (5) 2<sup>nd</sup> law equilibration, (6) 2<sup>nd</sup> law surface and volume, (7) 2<sup>nd</sup> law direction of heat flow, (8) Macroscopic heat flow, and (9) Graphing w/ ELabBook and/or MacTemp.

As difficulty and discrimination are mutually dependent, suggestions about a threshold value below which a question is raised about whether a particular item should be discarded from the assessment vary a bit, but range from .20 to .30 (Legg, 1991; Wollack, 2005; Michigan State University, 2009; Florida State University, 2011). Three observations from Table 10 are that:

- All of the posttest items had either difficulty, discrimination, or (in seven of 11 cases) both greater than .30, which supports the previous finding that the survey items were sufficiently valid but some would benefit from improvement if used in the future,

- All of the difficulty indices for survey A increased from *PreTest* to *PostTest* along with half of the indices for survey B, which suggests that the thermodynamics content questions got easier to answer, an encouraging result for a repeated measure, and
- The average improvement for the 2<sup>nd</sup>/4<sup>th</sup> hour classes was more than 3<sup>rd</sup>/6<sup>th</sup>; the improvement from both sets of classes is 6.0 points for 3<sup>rd</sup>/6<sup>th</sup> and 10.8 points for 2<sup>nd</sup>/4<sup>th</sup>, which are of dissimilar magnitude.

If survey B were a more difficult test than survey A, then we would expect that the scores for 3<sup>rd</sup>/6<sup>th</sup> would be higher in the *PreTest* than for 2<sup>nd</sup>/4<sup>th</sup>. But this was not the case: the *PreTest* scores for 2<sup>nd</sup> through 6<sup>th</sup> hour are 26.59, 21.50, 27.68, and 23.48, respectively, as portrayed graphically in Figure 2. With *MEAP* strongly correlated with *PreTest*, one would imagine that 3<sup>rd</sup> and 4<sup>th</sup> hour should perform comparably, and if 3<sup>rd</sup> hour students took an easier test then they would score higher. Looking at the improvement from pre to post when discriminated by class reveals more of a class effect: the increases for 2<sup>nd</sup> through 6<sup>th</sup> hour are 13.12, 2.35, 8.97, and 8.22, respectively. The increase for 4<sup>th</sup> and 6<sup>th</sup> hours are similar, even though they took the surveys in opposite order, which would not be expected if one test was more difficult than the other. Further, the increases for 2<sup>nd</sup> and 3<sup>rd</sup> hour are dissimilar from 4<sup>th</sup> and 6<sup>th</sup> but in opposing directions, 2<sup>nd</sup> outpacing the others and 3<sup>rd</sup> behind the rest. So the question is whether there is a class effect that causes a survey effect or vice-versa, and what the relationship between the two might be – is it a matter of one or the other, or are both present? In order to further test for effects on survey performance because of the class, an analysis of variance was performed for both survey administrations, and a significant effect was found for *PostTest* but not for *PreTest*, and the reason for this is the increased gap performance of the 3<sup>rd</sup> hour class from pre-project to post. However, if 3<sup>rd</sup> hour scores are eliminated from the ANOVA, then no significant interaction is found, which appears to spotlight a class effect rather than a difference in the difficulty of the surveys.

Attempting a statistical correction for a possible difference in how hard the surveys are would lead to unpredictable and even erroneous results if the effect of class is not able to be pinpointed. Therefore in calculations involving survey data with the predictor model, *Class* will be checked as a possible independent variable for the regression model along with *Race* and *Gender*.

### *Semi-Structured Interview Protocols*

A sample of 31 students from the total student population were interviewed prior to the beginning of the unit regarding their understanding of thermodynamics concepts and their motivation towards learning science and towards learning from computers. Half of these students are chosen on the basis of group scores from the first administration of the mMSLQ and half at the teacher's discretion. In the former case, mMSLQ scores for each group are tabulated and the highest and lowest scoring group in each class selected for interviews. In the latter case, two other groups from each of the four classes are selected based on the teacher's judgment; either the group consists of a historical high and low achiever, of two students who are motivated but not historical high achievers, or of two students who show signs of high aptitude but appear stymied by motivation. The interview protocols are located in Appendix A.

This same sample was interviewed at the conclusion of the unit, to help determine their growth in thermodynamics understanding. Due to attrition because of transfer or suspension, four of the original students could not be interviewed after the project, and three of them were replaced. Thus, there are 27 paired responses available for analysis.

The researcher conducted all of the interviews, and each student was asked for their permission to participate and for it to be recorded; no student declined permission at any time. During the interview, each student was asked three structured questions, two regarding thermodynamics understanding and one regarding the use of computer software. The interviewer is given leeway to follow up and probe the students' rationale for the answers they provide to these three questions. As in the case of the content surveys, there is an A and a B form of the protocol; unlike the surveys, there is a small change in one of the questions asked at pre-project and at post-project. The interview questions related to thermodynamics draw content validity from the fact that they were used in assessments in the course that the students had already experienced, as noted below.

The first interview question is directed at the second law, and is identical for each administration. The students are asked to manipulate small pieces of paper with words and clauses written on them into a sentence that makes sense to them – a word scramble. They are then asked to explain why the sentence makes sense, and are probed regarding their understanding of certain words and clauses. This exercise is essentially the same as the hammer activity in ELabBook, where the students identify the key thermodynamics concept targeted by the simulation.

A second interview question is identical to item 2) from the content surveys. Item 2) of content survey A is used for interview protocol B, and item 2) of content survey B is used for interview protocol A. This is aimed at the students' understanding of conducting and insulating

materials for heat transfer. The A content survey and A interviews are administered together, as are the B. As the content surveys are counterbalanced, so are the interview protocols; thus, the students do not answer an identical question on a content survey and an interview in close chronological proximity.

Prior to the project, the third interview question asks the student to describe a favorite piece of software. They are then asked follow-up questions about why they are motivated to use that software. Data from this question was examined but was not used in the study because it was meant to provide background information to the researcher. After the project, the student is asked why they were motivated to use ELabBook, and to compare ELabBook to their favorite piece of software. The greatest latitude in the quality of followup in the interview is allowed for this final question. This is a very open-ended question with no right or wrong answer, and its purpose is to allow students to express in their own words what they felt was motivating about using the technology.

The student responses to the thermodynamics questions are categorized according to a scale that ranges from "less complete understanding" to "more complete understanding." Responses to the first interview question are assessed according to a standard based on how well the sentence reflects an understanding of the second law and important terms such as "heat", "temperature", "heat energy", and "flow." One of the intended knowledge outcomes in this unit that was derived from the CLP initiatives was to help students understand the difference between the popular but ambiguous term "heat" and the more scientific terms "heat energy" and "temperature." Responses to the second interview question are assessed according to the same

rubric used in the content surveys. The categorizations of each student response based on interview transcripts and interviewer notes showing why a specific response was categorized are included in Appendices B (pre) and C (post).

Following the basic pattern of broad science assessments mentioned in chapter one (TIMMS, PISA, and NAEP), the scale used to rate the responses to the first two questions has four categories as follows:

- High understanding indicates that the student gives an answer that is fully compatible with accepted scientific understanding and in accord with the State of Michigan's Science Objectives (1991) for high school students.
- Moderate understanding indicates that the student gives an answer that corresponds to a proficient response, but which may have an error or an aspect of incompleteness. Moderate understanding is what was hoped the students would achieve at the conclusion of the project.
- Low understanding indicates that the student was able to formulate an answer with some grasp of the subject matter, but the answer does not really reflect a proficient response. Low understanding is what most students were assumed to possess prior to the study.
- A null response indicates that the student was unable to provide an answer.

The Wilcoxon signed-rank test will be used to track movement of students from lower to higher categories of understanding, to determine whether there was growth in thermodynamics understanding as evidenced by changes in answers to the interview questions between pre- and post-project.

The student responses to the computer use question are arranged according to how ELabBook rated in comparison to their favorite software. It is expected that students distinguish



between "school" software used for educational purposes, such as ELabBook, and "fun" software used for entertainment such as Doom™ and Wolfenstein™, popular games of that time. It is further expected that the latter genre frames their perspective of "good" software. The responses will show whether students ascribe a positive motivational influence to "school" software or if they see it as un motivating because it is not entertaining or colorful. There will not be a pre- to post- comparison for the computer question; instead, frequency counts for responses will be tabulated.

According to ANOVA calculations, the pre-project interview group (N=31) did not significantly differ from the entire population in the scores of *MEAP*, *PreTest*, *PostTest*, *Pop Quiz*, *Completeness Total*, *Attendance Project*,  $\Delta T$ , *Semester Grade*, *Race*, *Gender*, or any of the mMSLQ subscales (pre and post). Thus, their responses to interview questions may be reasonably accepted as representative of the entire set of students.

#### *Thermodynamics Pop Quiz*

This is a four-item quiz that is used to gauge how well students have understood the thermodynamics underlying the experiments that they have undertaken. The maximum score on the quiz is 20. Since all of the experiments were performed in groups, the quiz also represents an assessment of the accuracy of equation (2). No notice about the administration of the quiz was given to the students.

In the first item, the students are asked to write down the temperature of the fluid that they measured with the unmarked thermometers which they calibrated. In the second item, the

students are asked to sketch the cooling and warming curves generated in the temperature  $\Delta$  experiment. For the third item, the students are asked to indicate all possible directions of heat flow on a sketch of the apparatus used in the temperature  $\Delta$  experiment. Finally, the students are asked to describe the relationship between heat transfer rate and volume, a concept which arises from a comparison of the cooling and warming curves in the temperature  $\Delta$  experiment.

The pop quiz is scored according to a prescribed rubric, which is also included in Appendix A. The rubric includes both full and partial credit as well as a separate score denoting completeness, and was devised by the researcher.

With respect to reliability, Cronbach's alpha for the pop quiz is .53, and  $r^2$  for the quiz and survey A, survey B, and the standardized science test is .36, .46, and .51 respectively. Deletion of the first item did not increase alpha to .54, but deletion of the remainder does decrease it. The main reason for the dissonance of the first item is the absenteeism of students for the calibration experiment, which means they could not refer back to a temperature that they measured. Nevertheless, the reliability is far less than what is minimally required for a data measure, which is why the total pop quiz score will not be used in any further analyses in this study. Individual pop quiz item scores may be used when determining independent variables for the predictor model, but that will be the extent.

### *Insulating Device*

These artifacts consist of the final project design, which the students would perceive as the culmination of all the study undertaken in the unit. For the final project design, the students

were asked to design an insulating device, which was then tested by pouring a set amount of boiling water, taking temperature measurement at the start, and waiting for a prescribed time before measuring the temperature again. MBL probeware calibrated each day was used for the temperature measurements. The artifact is assessed by the value of the temperature drop, where a smaller number indicates a more successful performance of the device. The material list and design features of the device are not considered for the assessment. Students were allowed to make design improvements in their devices, and retest them multiple times. Only the lowest value of  $\Delta T$  was "counted" for the assessment. As noted in chapter three, the teacher stated that the class that had the lowest average temperature drop would receive a reward. A separate score for completeness is also determined based simply on whether or not the student tested a device. The MBL software MacTemp<sup>®</sup>, which is part of the first generation of probeware discussed in chapter two, was used to measure the temperatures because it purposefully has a faster and cleaner turnaround between measurements than ELabBook.

The students were free to discuss their designs with each other, and that was a purposeful decision to allow students to be able to learn from each other, as noted in chapter three. The teacher's idea to add a competitive element to the creation of more effective devices might have also encouraged information sharing limited to within classes – and hopefully it did not provoke the spread of disinformation. However, in any group setting there is always a risk that one student may be “along for the ride” or that a group may rely on advice from other groups in lieu of original thinking, and only soak in the minimum of whatever of procedural or propositional knowledge was needed to get the job done. Some of the analyses in this study will look at the students' first attempt with their device,  $\Delta T_1$ , as sometimes this is a better representation of their

thermodynamics understanding than the final product. The mean difference between  $\Delta T$  and  $\Delta T_1$  was  $1.5^\circ\text{C}$ , or about a 22% improvement, suggesting the usefulness of that type of analysis. The average number of attempts was 1.2. Harkening to the previous discussion of class effects, the 3<sup>rd</sup> hour class had the lowest number of participants to create an insulating device, 15, by far the highest mean  $\Delta T_1$  of  $12.2^\circ\text{C}$ , the greatest number of attempts, 1.5, and the highest mean  $\Delta T$ ,  $7.8^\circ\text{C}$ .

### *ELabBook Sections and Completeness*

For the ELabBook simulations and experiment, the assessment is based upon the notes made by the students as they worked through an investigative process scaffolded by the technology. The students performed several simulations and one experiment: the simulations are called *Demo*, *Potato*, *Cokes*, and  $\partial t$ , and refer in turn to a demonstration simulation meant to familiarize the students with the software while still investigating heat flow, a set of simulations where students choose materials that do the best job of insulating hot potatoes or cold cans of coke, and an experiment where the students investigate the second law of thermodynamics by measuring the temperature of a beaker of hot water that is inside a larger beaker of cold water. Each of the simulations was pre-configured according to best practices of the CLP curriculum (Songer, 1989; Lewis, 1991; Linn & Songer, 1991; Clark & Linn, 2003), while the experiment was designed locally but is aligned with a classic heating and cooling curve demonstration of the second law (Songer, 1989). Content validity for the ELabBook sections is drawn from this history.

After reading a description of the simulation at hand, the students work in lab groups of two (sometimes one if a lab partner was missing that day) and start by filling out a field in the software that predicts the result of the experiment (*Prediction*). They then prepare the section of the software dedicated to graphing by setting up the axes, establishing y-axis endpoints, x-axis time limit, axis labels, etc. (*Setup Axes*). Next, they choose the materials to be used and run the simulation; they may choose to do it over again if they wish without saving the data from the previous trial. Once the group feels they have satisfactorily completed the simulation, they perform a data analysis where they interpret the results of the simulation (*Graph Analysis*). The teacher can set this section up with a series of questions meant to guide the students' analysis – for example, asking which object cooled fastest in the initial simulation or experiment and what data supports it, which object cooled to room temperature first and what data supports that, and asking for specific temperatures at specific times. Images of the interface used within the teacher file to set up a simulation or experiment and the resulting screens that the students see are provided in Appendix D.

Next, the students are asked to perform an analysis of heat flow for the simulation, where they trace the direction of heat flow from one medium to another (*Heat Flow*). This is where the macroscopic model of heat flow endemic to the CLP curriculum as described in chapter two is first evidenced within the software. Once they complete that step, the group is asked to go interview another group that is performing the same type of simulation, and find out their results, and then come back to their own ELabBook and report the information (research from other groups, or *ROG*). Next, the students are asked to construct a sentence that relates the key principle of thermodynamics that the simulation illustrates (*Principle*). They are presented with a

screen consisting of a collection of pull-down menus standing in for the subject, predicate, and/or object of a sentence, with fixed text in between the menus. They are to make selections from each pull-down menu to eventually create a sentence that is scientifically accurate. For example:

Heat energy flows faster through a good conductor than through a poor conductor.

The pull-down menus could also have distractor options, and there could be more than one way of constructing a scientifically accurate sentence. This is sometimes referred to as the “hammer activity” because of the presence of a hammer-like icon on the screen. Students could also be asked to describe a situation from everyday life that could be explained with this principle, but their answers to that challenge were not assessed because of the variety of possibilities.

However, real-life examples were presented to the students as a class after the simulation was done.

The final step to completion of an ELabBook simulation or experiment is the conclusion section (*Conclusion*). The students are asked to compare their predictions with their data and to explain the basis for that comparison, to definitely state the material that worked better for insulating the object, and a reason why the material worked better, which could be the application of macroscopic heat flow. ELabBook stores all of the information entered by the student, and the researcher or teacher can then retrieve that student data from that computer or from another computer in the classroom through a variant of the ELabBook program that allows for lab administration.

Because the *Demo* simulation was meant to introduce the students to the process, it was limited to two options for insulating materials and did not have the *ROG* or *Heat Flow* sections installed.

The simulations and experiment are scored according to a specific rubric, which is also included in Appendix A. The rubric includes both full and partial credit, as well as a separate score denoting completeness, and was devised by the researcher but is very consistent with (and in most cases is identical to) what was used for the simulations in the CLP curriculum. The scores for the sections defined above were recorded for each simulation and experiment. The *Word Count* and *Completeness* scores were determined manually; if the lab group had a text entry for each section of the simulation or experiment, they were considered to have completed it. The count was determined by counting each word (including articles) that the students types into all of the fields.

#### *Group Contribution Survey*

This a five-item survey that allowed the students to describe their insulating device, some of the impetus for their ideas about that project, and a statement of the second law of thermodynamics. For two of the items, the students are asked to list the materials used in constructing their insulating device, and the major design features of importance in constructing the device. In a third item, they are also asked to estimate how well the workload was shared with their partner by making a selection from a list of choices ranging from "partner did no work" to "partner did all the work." In a fourth item, they are asked to list the two most helpful external sources of information in designing their project, choosing from a list of choices

including themselves, their partner, other students in class, ELabBook, the teacher or researcher, or their family or other friends. Finally, they are asked to state the second law of thermodynamics in their own words.

The most important data from this survey are the middle items described above, the division of responsibility and primary source of help. In this latter category, the standing of ELabBook against other sources is examined. The responses regarding the design of the insulating device and the second law are noted but not used in this study. Scoring for the two items of interest is made by assigning a categorical value to each of the students' choices, and determining the frequency of response for each category.

### **General Threats to Validity**

Campbell & Stanley (1963) discuss the threats to validity of one-group, test-retest and time sequence designs. Threats to validity occur when rival hypotheses plausibly explain an impetus for change in measured data from pretest to posttest beyond that of the treatment. The threats to the time-series are a subset of those to the test-retest design. Campbell and Stanley summarize the threats to internal validity as follows:

- *history*: the possibility that an external event experienced in common by the sample group between the pretest and posttest confounds the hypothesized cause of change, the treatment
- *maturation*: similar to history, except that the common event or process is internal to the individuals comprising the sample group



- *testing*: the possibility that the pretest itself serves as a learning aid or an impetus for change, thus leading to a more successful score on the posttest
- *instrument decay*: the possibility that a change in the instrument or in the assessment method from pretest to posttest biases the measurement
- *regression to the mean*: the phenomenon whereby an individual scores at an extreme on a test, and then scores at less of an extreme on a retest; the rival hypothesis is given as lack of correlation between the two test occasions (Smith & Glass, 1987)
- *selection-maturation interaction*: similar to maturation, except that the common event or process affects the group as a whole

Smith & Glass (1987) maintain a lengthy list of threats to external validity, which are broadly summarized as follows:

- *population*: questions whether the researcher can show that the sample population is an unbiased representation of the target population
- *ecology*: questions whether the researcher can show that the setting in which the study takes place is representative of the setting of the target population
- *operations*: questions whether the researcher can show that the study can be reproduced by a different researcher using a similar methodology

Each of these threats to validity is reviewed within the framework of this methodology; maturation and selection-maturation interaction are reviewed together. Issues of statistical conclusion validity are addressed within the context of the description of the analysis in chapter five.

### *History*

This threat is applied to designs without a control group. In Chapter one, a rationale was given for why a control group is not used in this study. The possibility of students undergoing external influences on learning apart from the treatment is bounded by the degree to which the

students are isolated from those influences. In a field study such as this one, such isolation is detrimental because it reinforces any separation between "in-school" and "out-of-school" knowledge that students already possess. Philosophically, knowledge should be integral and not differentiated in this way, hence the connections in ELabBook or the instruments to real world phenomena.

In the Group Contribution Survey, the students are asked to list the two most helpful sources of information in designing the insulating device from a list of eight options with the option of selecting "other." The most popular answers were ELabBook (N=41), their lab partner (36), and their own common sense (26). The least popular answers were outside influences such as family (3) and "other" (2). As a reminder, there was no textbook employed in this unit, so there was no ready opportunity to gain understanding from reading a text. For better or worse, external influences such as texts were likely not a factor in this study.

### *Maturation*

This threat is applied to the same category of designs as history. There is no sure way of gauging whether or not maturation played a role in shaping student scores apart from the treatment, or whether maturation and selection interacted to produce a similar effect. One argument in favor of an influence of subject maturity outside of the curriculum would be if all measured effects were to show maturity. However, this was not the case; for example, in chapter five, it is seen that some motivation variables did not change. As the length of the project spanned approximately ten and a half weeks, it is assumed that any background maturation

processes or interactions which operate apart from the influence of the project are negligible or beyond the scope of this study.

### *Testing*

Cook & Campbell (1979) suggest that this threat to validity occurs when students are able to remember items and error responses from the initial test when they are retested. The magnitude of this threat rises each time the same test is administered; it diminishes as the time between test and retest increases. In this study, the only test-retest condition where the instrument remains the same from one administration to the next is the mMSLQ. It is assumed that the eleven week interval between test and retest was sufficient to allow the students to forget their initial answers.

Campbell & Stanley (1963) emphasize the importance of using nonreactive tests that are passive measures of a construct. The danger cited is that of an effect whereby the testing process alone acts as a stimulus to change. However, in this setting the converse appears more of a concern, a setting where students have a tendency to be less mindful on tests and surveys, or even to not complete them. Perhaps unlike the typical students of Campbell and Stanley's time, some of these students demonstrated a history of bypassing major class assessments prior to the start of the project.

### *Instrument Decay*

Cook & Campbell (1979) suggest two sources of instrument decay. One occurs when the instrument changes from measurement to measurement. The other occurs when the gradations of the scale change. Both of these sources are plausible in this study.

As noted above, the mMSLQ is the only instrument that remains unchanged from one administration to the next. In all other cases, the instruments or the rubric changes from test to retest in order to accommodate other methodological concerns, environmental matters, or epistemological considerations which take precedence. For example, the artifact assessments engage ELabBook simulations and experiments along with the insulating device. The same knowledge constructed through the ELabBook tasks is applied in the design of the device. However, the artifacts themselves are qualitatively different, and not recognizable to a single mutual assessment. Each of the instruments is used to measure one aspect of science understanding.

As stated earlier, a philosophy of data triangulation from multiple measures is employed in this study, which means an answer to the research questions about science understanding consist of the sum of the outcomes of individual arguments made surrounding each of the measurements. The role of the various rubrics in this study is to standardize the assessment from student to student and measurement point to point. Of all the rubrics, the content surveys are most subject to variance in grading because they take longer to score and the scoring is more complex with the possibilities for partial credit. That is why an interrater reliability analysis for the content surveys was needed to resolve this issue. The same logic can be used for motivation,

which is operationalized along five dimensions in this study. Again, each motivational instrument is used to measure one dimension of motivation, and cases for or against motivational influences consist of the sum of outcomes of particular arguments along each dimension.

Changes in the gradation of the scale are most likely on those instruments where the students play a large role in defining the scale. For example, on the mMSLQ the 7-point Likert scale ranges from "not at all true of me" to "very true of me." This is a case where the student defines the gradations, and there is little or no external clue given if they choose to impose a ceiling or floor effect where the gradations are larger in the middle and smaller at one end or both. Pintrich & de Groot (1990) suggest that self-report surveys like the MSLQ can measure student perceptions of motivation, but that the results need to be replicated with other measures. In this study, the results of the mMSLQ are not always directly corroborated elsewhere, hence this endures as a weakness. However, effects such as hedonic bias may be noted in comparisons between mMSLQ subscales and science understanding assessments. The archetype would be a student who scores poorly on the content survey or did not create an insulating device, but reports a relatively high degree of self-efficacy in science on the retest.

### *Regression to the Mean*

Campbell & Stanley (1963) note that these regression effects are more likely if the sample group has been selected for their extremity. One type of analysis which might fall into this category are academic or motivational comparisons that involve the interview group alone, but no such comparison is planned. Campbell and Stanley advise the use of time-reversed control

analyses as a precaution against misinterpreting a regression effect. Such an analysis will accompany any calculations that might involve this kind of group.

### *Population*

The outcomes of this study are primarily intended to address the culpability of computer technology in a population of students deemed to be "at-risk." As noted in chapter two, there are no absolute definitions of an at-risk student, hence the difficulty in statistical generalizations about the sample population of students is intensified if a generalization to a broad target population such as all eighth grade students in America is attempted. Instead, the generalizability of this study stems from the connection between of the least common denominator with Universal Design. Technology that scaffolds or motivates learning for all students should also do so for the at-risk student, and vice-versa.

### *Ecology*

This setting is believed to be atypical of an eighth grade computer culture of that time in terms of availability and student erudition. Smith & Glass (1987) suggest that noncomparability and novelty contribute to an overestimation of the generalizability of outcomes. Due to the level of sophistication of these students, it is believed that noncomparability and novelty contribute to an initial underestimation. More importantly however, given that the availability of computer technology in schools is on the increase, the proper contrast is between the makeup of this school's technological culture and the future makeup of the technological culture of the average middle school. The outcomes of the research questions at hand are appropriate for that comparison.

One issue that may distinguish the sample population from others is the perceived reactive arrangements. While other research efforts have been enacted in this school (Rubio, Krajcik & Canty, 1993; Ladewski, Krajcik & Harvey, 1994; Marx, et al, 1998; Ladewski, 2006), this study presented a very distinct atmosphere, particularly the construction and testing of the devices and assessments such as the mMSLQ and the content surveys. The physical presentation and administration of these assessments aroused some reaction among the students that something novel was ongoing. One factor that worked in favor of mitigating this phenomenon was the length of the project. It is difficult for a student to act like a "good subject" for that period of time.

The teacher and researcher were constrained by the usual constraints of resources, time, and other environmental variables familiar to educators in a school setting. For example, the computer lab was not freely available for use but had to be scheduled, and acquisition of overtime days successfully negotiated. Apart from the permission to conduct the study, carry out interviews, and receive demographic data, no unusual cooperation from school administrators apart was solicited or gifted.

### *Operations*

One of the threats to validity from this category comes from the design of the content surveys. The results of the survey are used to represent the students' science understanding, but some of the data described earlier in this chapter suggests that the adequacy of survey B was on

the edge of being acceptable. It could use some improvement in one or two items prior to being used again.

An additional threat to operational validity is the effect of the researchers' involvement in the study. Several of the students expressed positive affect for the visiting researcher from Berkeley as well as for this researcher. It is conceivable that this affect translates into some increased enthusiasm, hence motivation and mindfulness.

### **Summary**

The methodology for this study has been presented in terms of four research questions about thermodynamics understanding, and scaffolded learning and motivation mediated by technology that will be analyzed and studied from a triangulation of data. The results of these analyses will be presented in chapter five. The setting for the study has been defined, along with the data measurement tools used. Issues of reliability and validity have also been addressed; most of these have either been bounded by suggested statistical means or tempered by logical argument, but the effects of maturity and operations remain open.



## **CHAPTER 5**

### **RESULTS**

The focus of this chapter is an analysis of the data collected during the project to answer the research questions posed in chapter one. The essential question is whether there was evidence found that eighth grade students in a diverse school environment undertaking a project-based thermodynamics science unit and using a well-regarded technology tool with scaffolded learning support were able to learn science. The answer to that appears to be “yes.”

The details embedded into the remainder of the chapter are intended to reveal the extent to which the basic model for increased science understanding presented earlier in this thesis holds true, and to explain why. This is primarily addressed by the creation of regression models founded upon the basic one that predicts science understanding as measured by both the posttest score and the temperature drop of the insulating device, with the hope that both regression models have the same predictor variables.

As a reminder, the basic model (graphically portrayed in Figure 8 later in this chapter) proposes that a project-based curriculum inclusive with a technology tool such as ELabBook that accounts for students’ prior understanding, engages student motivation, and scaffolds development of skill and knowledge growth will result in increased science understanding. For

this particular curriculum and tool, it is also important to uncover any changes in science understanding by race or gender because there is a national imperative to identify educational technology that demonstrably helps all students learn.

### *Summary*

A summary of the findings related to the four research questions is provided as follows:

1. Did student understanding of thermodynamics increase, given this particular classroom environment and high effort in the use of technology?
  - Yes, because there was a significant increase in the average aggregate paired score of all students from *PreTest* to *PostTest*.
  - Yes, because there was an increase in the average item-wise score of all students from *PreTest* to *PostTest*; the increase was significant for 33% of the items.
  - Yes, because there was a significant improvement in student understanding on two science items for a representative sample of students from *PreInterview* to *PostInterview*.
  - Yes, even though one class of students registered a markedly lower performance both in using ELabBook and on understanding science as demonstrated by test scores and initial values of temperature difference.
2. What motivational or scaffolded learning aspects (as identified in chapter two) of the technology played the most important role in increasing understanding?
  - Overall ELabBook scores were significantly and positively correlated with all post-project measures of science understanding; since ELabBook preceded these measures, probable cause may be implied; students in one class section (third hour) who had the lowest ELabBook total score also had the lowest  $\Delta T_I$  values and *PostTest* scores.
  - Variables corresponding to the prediction of the outcome of an ELabBook simulation, the proper setup of the charting area of ELabBook, and success in drawing a conclusion after analyzing the results of an ELabBook simulation were all predictors in the various regression models; however, no ELabBook variables were common to all the models.

- The total score for an individual ELabBook section that was most highly and significantly correlated with  $\Delta Test$  was *Setup Axes*; the one most highly and significantly correlated with *PostTest* was *Research from Other Groups (ROG)*; the one most highly and significantly correlated with  $\Delta T_1$  was *Prediction*.
  - When looking at just the group of students who participated in building an insulating device, the only significant correlations for race or gender favored White students for *ROG* and Black students for *Belonging*.
  - The largest number of positive responses by students regarding the use of the MBL software pertained to interest, ease, and realism; the largest number of negative responses concerned speed, the built-in notes feature, and the lack of an engaging user interface.
3. Was the use of technology more academically motivating to the students?
- For all students, feelings of potency increased across the project, while feelings of usefulness of science and belonging decreased; this suggests that motivation as a whole decreased slightly as a result of MBL use.
  - Feelings of competence in science, belonging, and potency positively affected or were positively affected by the science knowledge as demonstrated by the performance of a students' insulating device.
  - Feelings of competence in science, usefulness of computer use, belonging, and potency affected or were positively affected by science knowledge as demonstrated on a students' PostTest.
4. What were the interactions of race and gender upon content understanding? What features of the study, including the technology, were most beneficial or detrimental to underserved students?
- White students scored significantly higher than African-American ones on *PreTest*, *E LabBook Total*, *Pop Quiz Total*, and *PostTest*. Female students scored significantly higher than males on *E LabBook Total*,  $\Delta T$  (but not  $\Delta T_1$ ) and *PostTest*. African-American students had lower (better) values of  $\Delta T$ .
  - African-American students had a significantly higher feeling of belonging, and White students had a significantly higher feeling of potency. Female students had a significantly higher feeling of potency than male students.
  - Improvement from *PreTest* to *PostTest* ( $\Delta Test$ ) was not significantly related to race or gender, suggesting that all students were able to learn across the course of the project.

- Whites had significantly higher individual ElabBook section scores across the board; Female students had significantly higher scores than male students for *ROG*, *ELabBook Principle*, and *ELabBook Conclusion*.
- The students in the one class section with the lowest ElabBook total score, lowest  $\Delta T_I$  values, and lowest *PostTest* scores was also the only one with a majority population of both African-American and male students.

### *Did All Students Learn Science?*

Watson (2007) suggests that if there were a version of the Hippocratic Oath for academia, three of its tenets would be to strive to tell the truth, take care in establishing the truth, and do no harm (e.g. do not exploit human subjects). For the purpose of this study, it is important that these three tenets play out in an examination of a basic question: did all students learn science during the course of this unit? Regardless of how the findings of this research study may or may not be profound to the academic profession, it is morally correct to explore and report whether the students who spent nine weeks of their life learning thermodynamics were served and not harmed by this educator. Fortunately, the evidence presented below suggests that all students did improve their thermodynamics understanding through the course of this study.

The primary instruments used to gauge science understanding are the students's *PreTest* and *PostTest* scores, the difference between those two scores for each student,  $\Delta Test$ , and the temperature drop of the students' insulating device,  $\Delta T$ . There were 103 students for whom data was taken in this study, not all of whom were enrolled in the school during this time. Of that population,

- 57 were White (55%) and 46 were African-American (45%);
- 55 were Male (53%), and 48 were Female (47%); and

- 26 were in the 2<sup>nd</sup> Hour class (25%), 23 in 3<sup>rd</sup> Hour (22%), 26 in 4<sup>th</sup> Hour (25%), and 28 in 6<sup>th</sup> Hour (27%).

Table 11 shows data that represents the thermodynamics understanding of this student population.

Table 11

*Data Representing Thermodynamics Understanding of Student Population*

	N	Mean ± StD	Min	Max
PreTest	92	23.9 ± 11.2	2	55*
PostTest	89	33.2 ± 14.6	5	63*
$\Delta$ Test (PostTest – PreTest)	80	9.0 ± 12.2	-16	36
$\Delta$ T Project	72	6.4°C ± 3.52°C	2.6°C	18.5°C

Note: the largest possible test score is 90.

The mean value of  $\Delta$ Test is a positive 9.0 scale points for all students, which indicates that in the main, the students registered a learning gain. Translated to percentages, the mean *PreTest* score is 26.6%, while the mean *PostTest* score is 36.9%, an improvement of 10.3 percentage points or 39%. The absolute scores suggest an unsatisfactorily low level of student understanding of the thermodynamics content. However, in chapter four it was noted that the percentage of students who scored satisfactory or proficient in science on the MEAP falls into a similar range. Linn & Hsi (2000) reported that over eight versions of CLP-based curriculum, “the percentage of student responses that matched a scientifically normative view” increased (ranged) from 12% to 49%, with the middle versions at 26-28% (p. 52). These middle versions roughly correspond to the version of CLP that was utilized during this project. Even today, middle school science student performance in absolute terms appears low. For example, Herrmann-Abell & DeBoer (2011) found that middle school students correctly answered 39% of questions related to

conductive heat flow and 28% of questions related to conservation of energy. More generally, the National Assessment of Educational Progress (2011) indicates that 37% of all Michigan eighth-graders scored at a level of proficient or better in science, which drops to 21% for students from low-income families and 6% for African-American students. The student population at this school district consists of many from both of these groups. Perhaps low absolute scores in science for eighth graders is a distasteful reality.

Looking for a silver lining, a mean *PostTest* average of 36.9% is in the same strata as the other assessments noted above. In the light of these comparisons, the researcher in me will continue to look for evidence of success in improved learning, even as the educator in me is disappointed that the learning gain was not greater. The educator in me can be mollified by additional findings by Herrmann-Abell & DeBoer (2011) that high school and university students enjoyed improved understanding of these same concepts, indicating that improved understanding of thermodynamics is likely beyond what is learned in the middle school classroom.

Figure 12 shows a histogram with values of  $\Delta Test$  for the eighty students for which we have paired samples. In this study, 75% of the students registered a positive  $\Delta Test$  score. The interval width is two points, and the 75<sup>th</sup> percentile

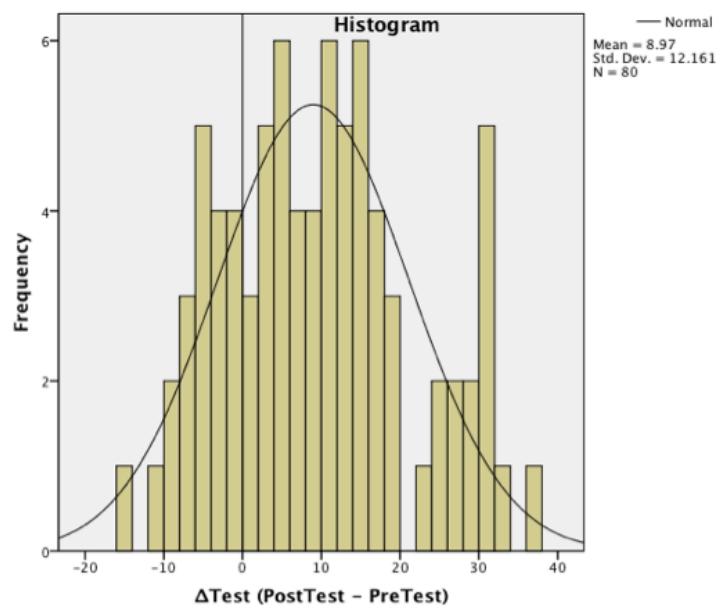


Figure 12. Frequencies of  $\Delta Test$  Scores

corresponds to  $\Delta Test$  values of 15-16 points. The superimposed line indicates a normal distribution whose peak is well into the positive range of  $\Delta Test$ , and suggests that the histogram reasonably follows that distribution although it also has characteristics of bimodality.

Evidence of increased understanding was also measured in the interview sessions that took place before (*PreInterview*) and after (*PostInterview*) the unit. As noted in chapter four, there were 27 students for which a paired measure is available. The first two interview questions and corresponding activities pertain to thermodynamics understanding.

The first interview activity was the word scramble, which included words that identically matched the principle or “hammer activity” that the students completed as part of the ELabBook temperature difference experiment. Enough words were present to allow students to make a statement about heat energy flowing “in” or “out” of a hot or cold object. Some additional words that had no scientific basis, such as “cold energy”, were part of the scramble as well to provide discrimination against lucky sentence construction. Interestingly, there were no significant correlations between the variables associated with  $\partial T$  Exp and the *PostInterview* answers. The full transcripts for the interviews and ratings of student responses are available in Appendices B (*PreInterview*) and C (*PostInterview*).

The statistical comparison used for the word scramble interview question is the Wilcoxon signed-rank test. The test showed that there was a statistically significant improvement from *PreInterview* to *PostInterview* ( $Z=-2.67$ ,  $p=.008$ ), as there were eleven students who improved

their understanding, two students who “went backwards,” and 14 who did not change; one of the fourteen registered high understanding on the PreInterview. Table 12 shows the crosstabulations.

Table 12

*Crosstabulations for PreInterview and PostInterview, Heat Flow Word Scramble*

		PostInterview				Total
		Null	Low	Moderate	High	
PreInterview	Null	1	4	0	3	8
	Low	2	12	1	3	18
	Moderate	0	0	0	0	0
	High	0	0	0	1	1
	Total	3	16	1	7	27

There were two versions of the second interview question, which matched the second item on the PreTest and PostTest surveys, as noted in chapter four. As a reminder, students were either asked whether specific materials were better for keeping things hot or cold, or whether in general materials that kept things warm also kept things cold. The goal was to determine whether students understood that the insulating and conducting value of a material was the same regardless of the temperature of the object which it was insulating or conducting. The ElabBook simulation *Coke* was directed right at the most difficult aspect of this concept, that an insulator such as wool which is effective for keeping something warm is equally effective at keeping it cold. Many students could believe this to be true about aluminum foil and styrofoam, but often felt that wool would only keep things warm and not do well at keeping them cool. There was a significant correlation between the scores for *Coke Conclusion* ( $r = 0.44$ ,  $p < .05$ ) and the *PostInterview* answers. The full transcripts for the interviews and ratings of student responses are available in Appendices B (*PreInterview*) and C (*PostInterview*).



The Wilcoxon signed-rank test was also used to compare *PreInterview* and *PostInterview* data for the second question, and again showed a statistically significant improvement ( $Z = -2.40$ ,  $p = .016$ ), as there were twelve students who improved their understanding, three students who “went backwards,” and 12 who did not change; none of the students registered high understanding either time. Table 13 shows the crosstabulations.

Table 13

*Crosstabulations for PreInterview and PostInterview, Conductor/Insulator*

		PostInterview				Total
		Null	Low	Moderate	High	
PreInterview	Null	0	3	2	0	5
	Low	0	11	7	0	18
	Moderate	0	3	1	0	4
	High	0	0	0	0	0
	Total	0	17	10	0	27

As additional evidence of overall improvement in science understanding, it was determined that scores for each of the nine items that comprise the *PreTest* and *PostTest* individually increased. In chapter four, these nine items were mapped to the principal sub-questions and corresponding science content in the unit. That table is replicated in Table 14, along with mean item difference scores,  $\Delta Test$ , and mean *PostTest* scores for each of the nine. Both are included to allow for a comparison of the change with respect to the raw score. The items are listed by descending mean for the item difference.

Table 14

*Mean Improvement on Test Items with Mean PostTest Item Score*

Project	Sub-question	Concept	Requisite Knowledge	$\Delta$ Test, PostTest scores (Mean Score $\pm$ StD)
	"What is heat?"	1 - Macroscopic model of heat flow	heat flows within and through different materials at different rates	$2.8 \pm 4.0$ ( $\Delta$ T)
	"How does heat behave?"	2 - The second law of thermodynamics	a larger surface area and a smaller volume will result in higher heat transfer rates	$5.3 \pm 3.3$ (PostTest)
	"How does heat behave?"	3 - Insulators and Conductors	a material works equally well to keep hot things hot as to keep cold things cold	$2.0 \pm 3.7$
	"What is heat?"	4 - Energy Conservation	Energy is conserved as it changes from different forms to heat	$4.3 \pm 2.9$
	"How does heat behave?"	5 - The second law of thermodynamics	heat energy flows continuously from the warmer body to the cooler	$1.0 \pm 2.4$
	"How do you measure heat?"	6 - Measuring devices, Calibration	a thermometer may be used when it has been calibrated for the temperature range of interest	$3.7 \pm 2.4$
	"How does heat behave?"	7 - The second law of thermodynamics	the temperature of all objects in a closed room (assuming none are heat sources) will come to equilibrium	$1.0 \pm 5.2$
	"How do you measure heat?"	8 - Using ELabBook, Using MacTemp	graphical interpolation	$4.6 \pm 3.0$
	"How do you measure heat?"	9 - Temperature scales	temperature is a measure of the amount of heat energy in a material	$0.68 \pm 3.4$
	"How do you measure heat?"			$3.49 \pm 2.8$
	"How do you measure heat?"			$0.63 \pm 4.1$
	"How do you measure heat?"			$3.3 \pm 3.0$
	"How do you measure heat?"			$0.57 \pm 3.2$
	"How do you measure heat?"			$2.8 \pm 2.7$
	"How do you measure heat?"			$0.35 \pm 4.6$
	"How do you measure heat?"			$3.7 \pm 3.3$
	"How do you measure heat?"			$0.24 \pm 2.9$
	"How do you measure heat?"			$2.0 \pm 2.0$

Note: for  $\Delta$ Test, N ranges from 81 to 84; for PostTest, N ranges from 89 to 90.

The left-hand column shows how each of the items relates to the major sub-questions that are addressed in the unit plan shown in chapter three. Aggregating the mean  $\Delta$ Test scores

according to sub-question by adding the mean score for all items pertaining to a sub-question in Table 14 and dividing by the number of items, and then comparing them shows the greatest increase in understanding in answering the question, “what is heat?” (1.9), followed by “how does heat behave?” (1.1) and finally, “how do you measure heat?” (0.41). A comparison of *PostTest* item scores using the same methodology produces the same order: what is heat (4.45), how does heat behave (3.6), and how do you measure heat (3.0).

Based on the above evidence, one may conclude that all students did learn science during the course of this unit.

#### *The Effect of Scaffolding on Knowledge Gain*

The effect of scaffolding through the MBL on knowledge gain will be probed in two ways. The first is to look at how well student performance on the MBL simulations and experiment correlates with performance on the primary measures of knowledge, the content survey and the efficacy of the primary artifact, the insulating device. The second is to examine interview data from thirty of the students after the completion of the unit, to see what they thought were the most valuable aspects of the use of technology.

As discussed in chapters two and three, the first and second project questions discussed above, “what is heat?” and “how does heat behave?” are directed areas of knowledge growth within the CLP curriculum and have the largest degree of scaffolding embedded in ELabBook, while the requisite knowledge for the third question, “how do you measure heat?” was supported by ELabBook insofar as the students had to be able to calibrate the probes for an experiment

and/or setup the axes for a simulation or experiment. Helping students to grasp a scientifically correct macroscopic model of heat flow is one of the primary emphases of the CLP curriculum, and hence the ELabBook software is designed to concentrate the students' attention on understanding heat flow. For example, each of the simulations and experiments include a section where the students name the direction of heat flow, and why. There is another section where students ascertain the scientifically accurate conclusion for the experiment, and their performance on this item was also tracked. As noted in chapter four, student scores were also tabulated for other sections such as predicting the result of the simulation or experiment, setting up the axes for the plots, analyzing the plots to understand how they represent the simulation or experiment, describing the thermodynamics principle that underlies the behavior seen in the simulation or experiment, and checking in with another lab group to see their results. The rubrics for scoring each of these are shown in the appendix.

An attempt was made to correlate the item difference score, the PostTest item score, and the initial and final values of  $\Delta T$  with the section scores from the ELabBook simulations and experiment: prediction, setup of axes, graph analysis, heat flow, research from other groups, principle, conclusion, and overall score. The purpose of doing this is to identify the most "valuable" of each section or aspect of the MBL simulations or experiment in terms of student learning, and to determine whether any particular simulation or experiment contributed more than the others. The simulations and experiment include the demo, potato, and coke simulations plus the temperature difference ( $\partial T$ ) experiment. The Pearson correlation coefficient,  $r_p$ , is used to measure the effect of MBL on knowledge gain. The measures of knowledge gain are *PostTest*,  $\Delta T_{test}$ ,  $\Delta T$ , and  $\Delta T_I$ .

The drawback to this analysis is that the students received scores as a lab group rather than as individuals, so that differentiation between high and low achievers is mitigated – students who may have demonstrated low understanding on the tests were credited for scores indicating higher understanding on the simulation or experiment if they were paired with a partner who “did all the thinking,” a phenomenon that was observed and discussed in chapter three. Also, there is a tension between the accumulation of procedural and propositional knowledge, as was discussed in chapter four. Since groups did their testing publicly (within a class) in front of which other, were free to discuss design improvements for their insulating devices with each other, and were allowed as many retries as they wished, students who may not have known much about thermodynamic principles may have simply copied design features of others’ insulators when looking to create or improve their own. Looking at the initial value of  $\Delta T$  separately from the final value of  $\Delta T$  will help to understand this effect, as it is assumed that the students’ first attempt is based more solidly on their own knowledge base than on what may have been influenced by what other groups did.

Pearson correlations with two-tailed significance between the overall scores for the individual ElabBook sections and the measures of knowledge are shown in Table 15.

Table 15

*Correlation of ElabBook Section Scores with Knowledge Measures*

ELabBook Section	PreTest	$\Delta$ Test	PostTest	$\Delta T_1$	$\Delta T$
Prediction	r = .37	r = .27	r = .50	r = -.42	n.s.
Set Axes	r = .30	r = .39	r = .53	r = -.32	r = -.38
Graph Analysis	r = .52	n.s.	r = .51	r = -.36	n.s.
Heat Flow	r = .49	n.s.	r = .52	r = -.30	r = -.27
Research from Other Groups	r = .44	r = .29	r = .57	n.s.	n.s.
Principle	r = .44	r = .22	r = .51	n.s.	r = -.27
Conclusion	r = .50	n.s.	r = .54	r = -.29	r = .26
Total	r = .53	r = .24	r = .59	r = -.34	r = -.28

Values of N range from 72 to 91; Correlations of  $\pm .21$  or greater are significant at  $p < .05$ ;  $\pm .29$  or greater at  $p < .01$ ;  $\pm .36$  or greater at  $p < .001$

Ideally, there would be one or more significant correlations between the ELabBook scores and each of the measures of knowledge. This was certainly the case with the total ELabBook score and each of the knowledge measures, as evidenced in the last row of Table 15. It was also true of the *Setup Axes* score, and in fact each of the individual ElabBook section scores were significantly related to at least three of the knowledge measures. There is an inverse relationship between the *ElabBook Total* score and both  $\Delta T_1$  and  $\Delta T$  because lower  $\Delta T$  values indicate greater success with the design of the insulating device, which is an experimental and experiential application of science knowledge. The proportional relationship between the *ElabBook Total* score and test scores indicates greater success for students proficient with ELabBook in applying the theoretical aspect of science knowledge. However, a significant relationship between ELabBook and both *PreTest* and *PostTest* raises the question of whether use of the technology actually correlates with an increase in knowledge for all students, or just

shows that technology primarily helps students who are already strong in prior understanding. This is why a significant correlation with  $\Delta Test$  provides an important clarification of this issue, as it suggests that success in learning with ELabBook is tied to improvement on the *PostTest* for all students.

It is important to note that success in understanding thermodynamics with ELabBook in one medium, which may also be viewed as successful learning with technology, translated to improved performance on both the students' paper and clinical assessments in other media. The ELabBook program is contained in an electronic medium, the Test scores took part through a traditional paper and pencil medium, and the  $\Delta T$  values were a consequence of work in a three-dimensional, kinesthetic medium. This is clearly a positive finding that supports the technological goals of the National Educational Technology Plan discussed in chapter one.

Figures 13-15 contain scatterplots with regression lines that show the relationships between the total ELabBook scores and the knowledge measures. It is useful to make such a graphical examination of the data to confirm that it is consistent with findings of the calculations described above – that the data “make sense.” As an addendum to the discussion of bias in chapter four, the fact that all of the ELabBook scores (data) in this study are based on group performance suggests the possibility that in a group consisting of high and low performing students, there are higher ELabBook scores for the low performing student than would have occurred otherwise; the converse may also be true, that scores for a high performing student may be lower than would have occurred otherwise.

Figure 13 confirms that the *PostTest* scores are more strongly correlated with the *Total* ElabBook score than the *PreTest* scores. One can do a columnar comparison between pre and post for a given *Total* score; dark dots higher up on a column of dots for a specific x-value indicates improvement from pre to post. There are two regression lines shown in Figure 13, and the one with the higher slope corresponds to the *PostTest*. The strongest significant correlation between an ElabBook section and

PostTest occurs with the *ROG* (*Research from Other Groups*) score, as reported in Table 15. This suggests that scaffolding of social interaction and knowledge construction was one of many strengths of the use of technology. The importance of this particular characteristic of science learning and corresponding scaffold was

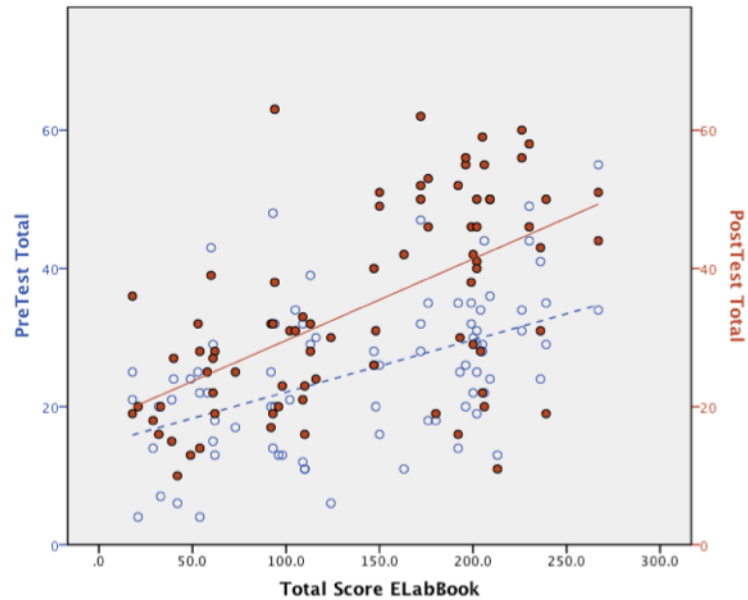


Figure 13: Relationship between ELabBook score, PreTest, and PostTest

already discussed in chapter two, so a statistical witness to its presence is welcome. To test the veracity of this correlation more thoroughly, *ROG* will be entered into the regression model for predicting the *PostTest* scores that will be discussed later in this chapter. While *ROG* may be singled out, all of the ElabBook section scores were well correlated with *PostTest*; in other words, each aspect of scaffolded learning in the program was tied to success on the *PostTest*. Harkening back to the question posed in chapter one of whether this software program could be used effectively among an at-risk population different from where it was initially developed and



tested, this showing of stability suggests the answer maybe yes. But more will be said about this issue in this chapter.

Figure 14 provides a similar confirmation for the correlation with  $\Delta Test$ . The chart includes a “ $y=0$ ” line, denoting no improvement from *PreTest* to *PostTest*. This line thus delineates between the larger

number of students who improved from *PreTest* to *PostTest* and the smaller number who did not. The dashed regression line indicates the positive relationship between performance within ELabBook and score improvement for all students, not just ones with strong prior understanding. Table 15

indicates that the strongest

correlations between an ELabBook section score and  $\Delta Test$  were with *Set Axes*, *ROG*, *Prediction*, and *Principle*, respectively. The *Prediction* section may be reinterpreted as helping the student to predict the outcome of the simulation, the *Set Axes* section as helping with setting up for the simulation, *ROG* as discussing or confirming findings with others, and *Principle* as understanding the key thermodynamics concept that explains why the simulation had the outcome it had. Each of these four sections connects with the four science learning strands defined by Michaels, Shouse & Schweingruber (2008) in chapter two; the *Set Axes* section may

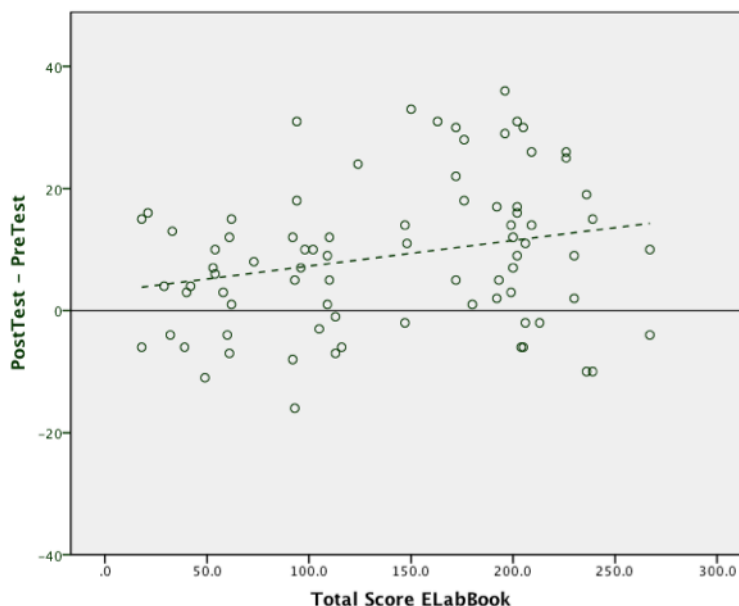


Figure 14: Relationship between ELabBook score and  $\Delta Test$

have only a weak connection to the strand of generation of scientific evidence, but it is a connection nonetheless. *Prediction* ties in well with understanding scientific explanation, *Principle* with reflecting on scientific knowledge, and *ROG* with participating productively in science. The reason for pointing this out is to associate the science learning strands with the scaffolded science learning within ELabBook, to link between effective science learning and effectively learning with technology.

Figure 15 shows that the ELabBook scores are more strongly correlated with the initial temperature drop of the insulating device,  $\Delta T_i$ , than the final value,  $\Delta T$ . Two comparisons were made, one with all data for both temperature drops included and one with outlier data identified statistically and

removed. This was done in order to allow a cleaner interpretation.

The outlier data is not present in this figure because it was the more conservative comparison.

As noted in chapter three,  $\Delta T_i$

was expected to be a purer

indicator of the applied

knowledge of the groups, because

after the initial round of designs and measurements, the “word spread” about which design characteristics of the devices seemed to play more key roles in reducing the temperature drop, and the resulting designs began to converge towards those characteristics. The regression line

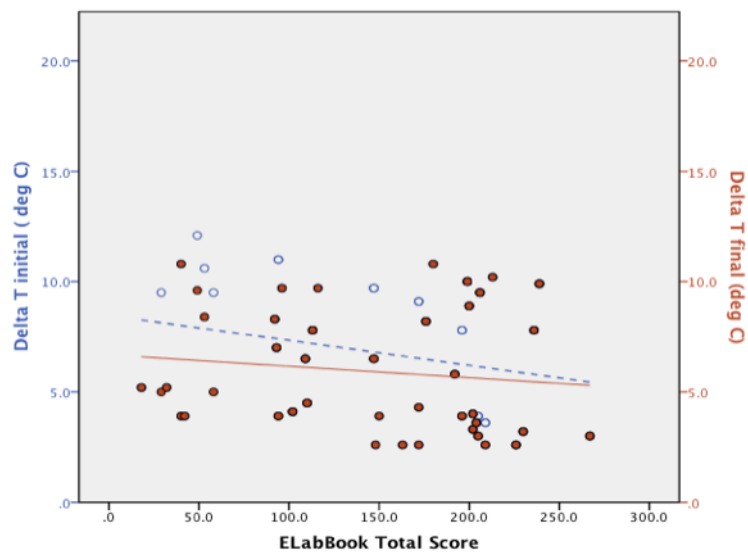


Figure 15: Relationship between ELabBook score,  $\Delta T_i$ , and  $\Delta T$

associated with  $\Delta T_1$  has a greater slope than the one associated with  $\Delta T$ . This confirms that knowledge developed from working with ELabBook was a stronger influence on the initial attempt to create the insulating device than on subsequent attempts when the influence of “copycatting” other students’ designs enters in. The reader is reminded at this point that the student groups were encouraged to do their initial designs on their own, and to then talk with each other about their successes and failures in order to redesign their devices. This was done to provide a role for scientific discourse once the students had a sufficient knowledge and experiential base to enter into that discourse.

Table 15 indicates that the *Prediction* section score was most strongly correlated with  $\Delta T_1$ , which is a welcome discovery, as one would expect that a person’s ability to do well in predicting the outcome of a simulation would also lead him or her to a superior initial design of an experimental device. Supplementing this finding is one of the results of the *Group Contribution Survey*, the ungraded survey given to the classes as described in chapter four. For one of the survey questions, the students were asked to list the design features of the insulating device that were most important to have, and why. The highest score on this survey was given to students who could list the features **and** provide explanations; lower scores were given for a feature list sans explanation, or for no response. The item score and  $\Delta T_1$  enjoyed a significant correlation,  $r_{pb}(71) = -.36, p < .01$ , but there was nothing similar with the item score and  $\Delta T$ . This supports the idea that students who did well on the initial attempt did so because they better understood the design features of the device, an understanding that was also measured by the *Prediction* section of ELabBook.

In the *Group Contribution Survey*, students were also asked to attribute the most helpful source of information in designing their insulating device. The list included various sources such as family, teacher, friends, lab partner, ELabBook, watching other students, using one's own common sense, or some other source. The mean  $\Delta T_l$  of students attributing ELabBook was the smallest of all groups (4.6°C, N=15), followed by attribution to the teacher (5.6°C, N=3); trailing the pack were common sense (8.2°C, N=11) and friends (10.2°C, N=3).

In looking at trends across each of the ElabBook sections, some interesting things come to the fore. A series of nonparametric comparisons of the section scores across time based on Freidman's two-way analysis of variance showed that the scores for prediction, setup of axes, and research other groups did not change with time while scores for all other sections, including total score and word count, did change significantly. Table 16 shows the outcome of this comparison, with the final column showing the results of the Friedman test.

Table 16

*Mean Rank of ElabBook Sections over Time*

ELabBook Section	Demo	Potato	Coke	$\hat{\sigma}_t$	Outcome
Prediction	2.30	2.43	2.45	2.82	n.s.
Set Axes	2.53	2.54	2.34	2.59	n.s.
Graph	2.77	1.66	3.27	2.31	p < .001
Analysis					
Heat Flow	3.67	2.34	2.01	1.97	p < .001
ROG	-	2.03	1.98	1.98	n.s.
Principle	-	2.28	2.15	1.57	p < .001
Conclusion	3.21	2.76	2.49	1.54	p < .001
Total	2.30	2.79	3.08	1.83	p < .001
Word Count	2.78	2.72	2.83	1.67	p < .001
Completeness	74%	75%	54%	58%	p < .001*

Rank ranged from 1 (lowest) to 4 (highest); N=96 students for the data in this table except for completeness, which ranged from 96 to 100.

\*Since completeness data are binary, the test statistic is based on Cochran's Q.

The consistency of student performance on the three sections that did not significantly change over time helps suggest why these sections have more prominent correlations with measures of science understanding; the more consistent performance stems from more consistent scaffolding. Completeness percentage was lower for the *Coke* simulation and the  $\partial t$  experiment, however the total mean rank and word count increased across each simulation before both dropped for  $\partial t$ . This suggests some bifurcation in the overall effectiveness of the MBL scaffolding: a majority of the class were growing in how to use this computer-based environment for learning, but a large minority were lagging in or stopping their use and thus seeing the benefit to their support reduced. These results are reminiscent of findings from Zhang & Quintana (2012) regarding the importance of scaffolding work across different work sessions as well as Roscoe, et al. (2012) that students gravitated towards a focus on certain ElabBook sections or scaffolds at the expense of others.

The student responses to the third *PostInterview* activity, which concerned their perceptions about the role and utility of the MBL in their science learning, could be categorized into nine characteristics. A brief definition and examples of student comments for each are shown in Table 17.

Table 17

*Important Attributes of ElabBook Identified by Students*

Attribute and Definition	Examples
<i>Multimedia</i> - The graphical interface, use of graphs, color, animations, audio	“[I] like the one thing where you type in something and you could make it talk.”
	“You should be able to do more things with it ... more graphics, more animation.”
<i>Challenge</i> - The overall difficulty of the ElabBook suite	“I thought I was going to get it wrong but I did my best, you know, I made my best decision and it turned out that I was exactly right ...”
<i>Social</i> - The interpersonal aspect of using ElabBook, either embedded in the program itself or in the learning environment surrounding the program	“I liked where ... when you have to ... where we collaborate.”
	“... some of them I didn’t want to do because my partner wouldn’t help me and I didn’t want to do them if he wouldn’t.”
<i>Realism</i> - The use of simulations and experiments to do “real” science; the contemporary context, materials, etc. involved in the simulations and experiments	“It was good because you also learned the different things which you have to do to get all your research, like if you wanted to be a scientist.”
<i>Ease</i> - The overall ease of use of the program (not to be confused with it being cognitively easy);	“If you need help you can go to ‘help’ and it’ll tell you where to go.”
	“Some people they messed up my computer when they was messing around with my part and they messed it up, so I had to do it all over again.”
<i>Notes</i> - The implementation of notes within the suite	“... it was cool because, you know, we used it in them notes. Sometimes you had to use your own opinion and what you think everything really does ...”
<i>Interest</i> - A general indication of interest or “fun” in using ElabBook	“They were kinda hard. I always had to think what to fill in.” “First I thought it was going to be boring, but when we got into it, it was kind of a little fun.”
<i>Variety</i> - The choices given to students to design their own simulations and experiments	“Then, all of a sudden it started getting boring during the last experiments” “... you go to do things instead of the computer doing them for you.”

Attribute and Definition	Examples
<i>Speed</i> - The speed at which the program runs; the frequency of crashes/restarts	“... it took so long for the program to gather all of its materials. Maybe, if you could get a computer that was a bit more powerful.”

The data for the post-interview responses are summarized in Figure 16. The vertical axis shows each characteristic, and the horizontal axis the number of responses that students gave about each characteristic, and whether those responses indicated a positive or negative perception of the computer-based learning environment.

The thirty students involved in the *PostInterview* made 59 positive comments about the MBL software, and 33

negative ones, a ratio of 1.8.

Three of the characteristics

did not elicit any negative

comments: *realism*,

*challenge*, and *variety*. Five

of the characteristics

engendered more positive

than negative comments,

which in order from high to

low are *realism*, *interest*, *challenge*, *variety* and *ease*.

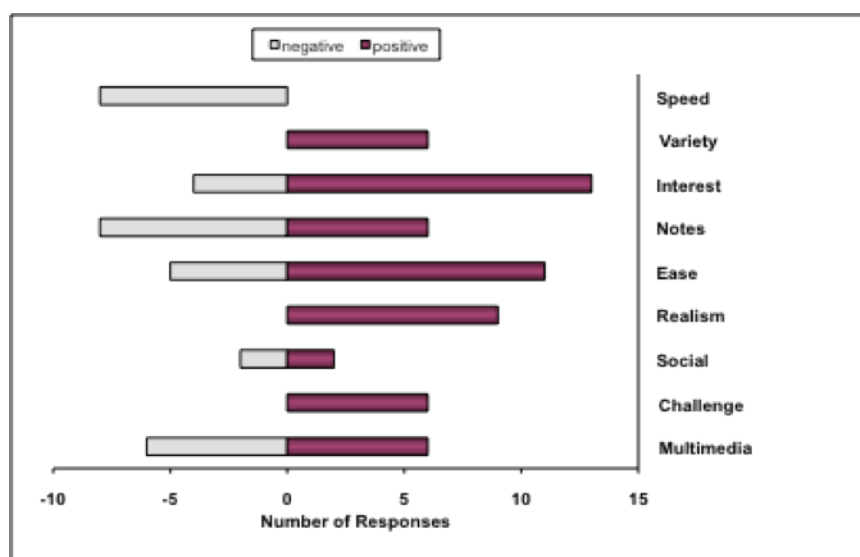


Figure 16: Summary of Responses for Student Perceptions of the CBLE

Four of these five characteristics are well-aligned with the intrinsically motivational features of technology that are discussed in chapter two; a fifth characteristic of *challenge*

emerges as a defining attribute which is related to the five, but is really affiliated with a curricular goal of this project to provide these largely at-risk students with an environment that would invoke higher order thinking. Each of the students who commented on this characteristic spoke about enjoying ElabBook because it was cognitively demanding. When asked about the value of the MBL software for classroom use, 13 of the students cited a specific scientific concept or process that the software helped them learn, and four other students cited the interactive nature of the software. Thus 17 of the 30 students provided an optimal response. The remainder of the students made general statements about ElabBook either being good for learning science, learning about computers, or both.

The remaining four characteristics either had equal positive and negative or mostly negative comments, which in order from neutral to low are *multimedia*, *social*, *notes*, and *speed*. One characteristic did not elicit any positive comments: *speed*. Both *multimedia* and *social* had an overall neutral response.

Most of the consternation about the *speed* of the software can be attributed to the use of computers that were 2-4 times slower than the state of the art at the time, plus the fact that the choice of HyperCard as the application platform carries an intrinsic speed penalty. The difficulty with *notes* was due to the students' wishes that they not be so repetitive. The responsibility here can be shared equally between students, myself, and the developers. In maintaining a design environment amenable for scaffolding, the software developers force some degree of repetition upon the teacher. As the person who created the notes, I clearly erred in including notes in the latter simulations and experiments that were too trivial. The students were also not used to



writing in a science class, and demonstrated some immaturity in objecting to being asked to construct and reflect upon written thoughts. In the area of *multimedia*, comments were aimed at the lack of color, animation and “pizzazz” especially in comparison to commercial software packages. This complaint is again based upon the choice of HyperCard; however in fairness to the developers of CLP it should be noted that ELabBook uses many advanced features of HyperCard, and facilitates a level of higher-order thinking that is either absent or vacuous in much of the commercial education software from that time that I have observed. Most of the comments related to the *social* characteristic had to do with the experience of working with their lab partner rather than any assessment of the value of having a social aspect built into the software.

#### *Academic Motivation*

Conclusions about the effect of motivation upon learning will be drawn by looking at variables that are indicators of the five constructs described in chapters two and four: feelings of competence, usefulness, optimism, belonging, and potency. As noted in chapter four, a principal components analysis of the eleven motivation variables showed that they loaded onto four components that aligned well with these feelings. However, a separate analysis of how significantly the individual motivation variables related with the outcome measures of understanding is the basis for determining how motivation will be analyzed in the model.

In the case of the principal components, correlations with prior knowledge variables were observed for optimism and potency, while correlations with knowledge outcome variables were detected for belonging and potency. The table of correlations is shown in Table 18.

Table 18

*Correlations of Science Understanding with Principal Motivation Measures*

Measure	MEAP	PreTest	$\Delta$ Test	PostTest	$\Delta T_1$	$\Delta T$
IV-SR-SE	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Belonging	n.s.	n.s.	$r = -.25$	n.s.	n.s.	$r = .32$
Optimism	$r = -.33$	n.s.	n.s.	n.s.	n.s.	n.s.
Potency	$r = .48$	$r = .60$	n.s.	$r = .45$	n.s.	n.s.

Note: N ranges from 82 to 91; Correlations of  $\pm .21$  or greater are significant at  $p < .05$ ;  $\pm .29$  or greater at  $p < .01$ ;  $\pm .36$  or greater at  $p < .001$

*Belonging*, *Optimism*, and  $\Delta T_1$  and  $\Delta T$  are inverse measures, such that a numerically lower score indicates a higher performance, so that each relationship is as one would intuit: a stronger feeling of belonging as measured by lower absenteeism correlates with better improvement from *PreTest* to *PostTest*, stronger belonging correlates with enhanced performance on the insulating device as measured by lower temperature change, stronger optimism as measured by lower anxiety correlates with higher standardized test scores, etc. As such, the table is a harbinger of which motivation constructs seemed to affect learning in this study.

The analysis for each of the individual motivation variables follows a set pattern. If the correlations across time (e.g. *Science Self-Efficacy Pre* and *Science Self-Efficacy Post*) and domain (e.g. *Science Self-Efficacy Pre*, and *Computer Self-Efficacy Pre*) are strong, it indicates a stable construct such that if one of the permutations of the construct is included in a multiple regression model it can stand in for all because one of the objectives of regression is to not include input variables that are strongly correlated. Next, the paired mean difference over time and domain (if applicable) will be examined to determine if the construct changed across the

course of the project, using paired t-tests with a significance of  $\alpha = .05$ . If there is a change, this is an indicator of a role that motivation played in this study, and there will be further elaboration on the relationship. Finally, correlations of the motivation measures to knowledge measures will be assessed in order to determine whether the motivational variable is a candidate for the regression model for *PostTest* and  $\Delta T$ .

In the case of a feeling of competence as represented by self-efficacy, each of the comparisons had a very significant correlation, meaning that there is a stable measurement of self-efficacy over time and domain. None of the paired mean differences were significant, so that self-efficacy was not differentiable by time or domain. Students who saw themselves as competent science learners also saw themselves as apt computer users, and their concept of self-efficacy was unchanged across the project.

There were two significant correlations between self-efficacy and the four post-project knowledge measures of *PostTest*,  $\Delta Test$ ,  $\Delta T_1$  and  $\Delta T$ , as follows:

- *Science Self-Efficacy Post* and *PostTest* with  $r(79) = .27, p < .05$ ; and
- *Science Self-Efficacy Post* and  $\Delta T_1$  with  $r(67) = -.25, p < .05$ .

This connects a feeling of competence in learning science at the end of the project with increased performance in both theoretical and experimental science knowledge. In chapter four, no such connection with self-efficacy was found at the start of the project. This means that the motivational effect of self-efficacy in science on performance will be further explored in the regression models for both *PostTest* and  $\Delta T_1$ .

For feelings of usefulness as represented by intrinsic value, each of the comparisons once again had a very significant correlation, meaning that there is a stable measurement of intrinsic value over time and domain. However, the paired mean difference for science decreased over time,  $t(82) = 2.11$ ,  $p < .05$ , meaning that students saw less value for science at the end of the project than at the beginning. The paired mean differences were also significant across domain, as the students had stronger feelings that computer use was more profitable than learning science at both the beginning and end of the project.

In support of this finding, there was one significant correlation between intrinsic value and one of the knowledge measures, *Computer Intrinsic Value Post* and *PostTest*,  $r(83) = .22$ ,  $p < .05$ . Taken with the above finding, this suggests that while all students generally found less intrinsic value in science across the course of the project, the ones that saw more value in computer use tended to do better on the *PostTest*. This presents a cross-domain connection of a feeling of competence in computer use at the end of the project with theoretical science knowledge performance. While on some level it would be more satisfying to instead see science intrinsic value in this position, this connection is possibly unique to a study of the use of technology in learning science. Computer intrinsic value will be studied further in the determination of the regression model for *PostTest*.

For feelings of optimism represented by anxiety and self-regulation, the correlations showed stability over time and domain. The paired mean differences over time were not significant, but they were for domain, as anxiety towards computer use was notably lower than

anxiety towards science both at the beginning and end. This finding is copacetic with what was previously determined for intrinsic value.

Recall from chapter four that anxiety was strongly associated with knowledge measures prior to the project. This did not prove to be the case at the end of the project. In fact neither anxiety nor self-regulation was linked with any of the post-project knowledge measures. Interestingly, science and computer anxiety prior to the project were both significantly correlated with *PostTest*, a finding that invites further analysis, given that in the chronology of the project, the final *mMSLQ* scales were administered after the completion of the  $\Delta T$  measurements and *PostTest* – when the students would have known exactly how well they did during the project.

Figure 17 shows the relationships across time between science anxiety and *PostTest*, where the dashed line indicates a significant correlation but the solid one does not. The same is true of Figure 18 for computer anxiety. Both plots show an overall leveling or tempering of anxiety across the course of the project between the higher and lower achieving students. The question is what type of motivational force is anxiety in this study – should it be the same for all students? If we are to accept that we will always have

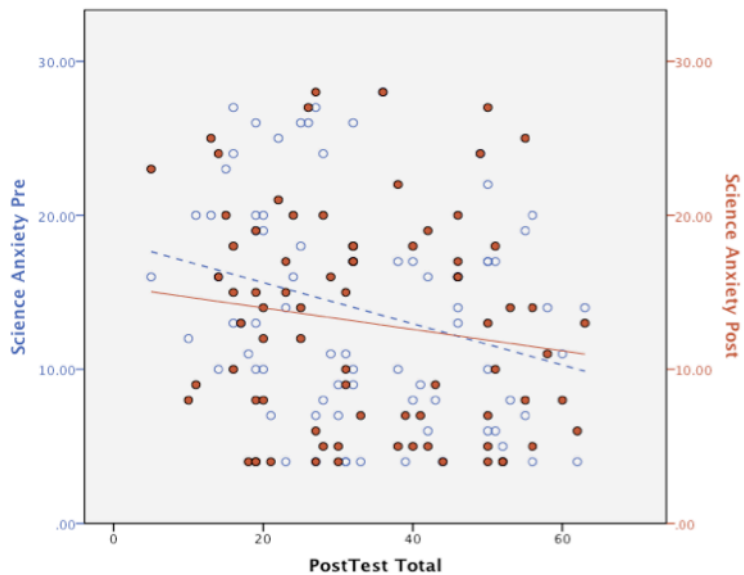
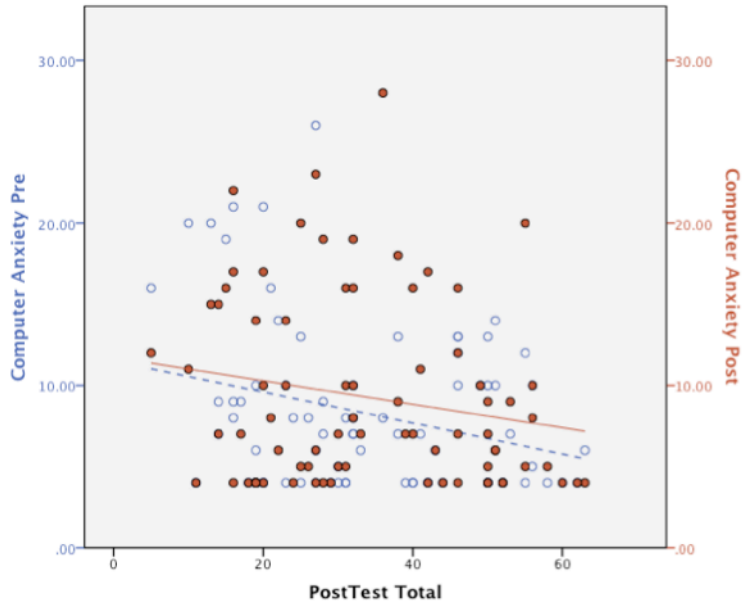


Figure 17: Comparison of Science Anxiety and PostTest Score

high and low achieving students as a reality in education, would it be acceptable for anxiety to function positively as a motivating factor when it increases in highly capable students and decreases or increases less in lower achievers? While the latter conclusion is consistent with what has been proposed in this study, Norem (2008) and others who have researched a positive motivational role for defensive pessimism would allow for this dual role for anxiety. The data above do not support any specific conclusions, but they do raise a flag for further study.



*Figure 18: Comparison of Computer Anxiety and PostTest Score*

Feelings of belonging over time and domain as reflected by measures of attendance also show stability. A comparison of paired mean differences indicates that students had significantly more unexcused absences during ElabBook or during the project than before it. In essence, students appeared to have a greater feeling of belonging outside of the project and ElabBook. This is not quite what one would hope to see happen if one of the goals of using MBL was to help all students learn. However, considering the results of the pre-project motivational comparisons, it is possible that the project polarized the class from a motivational standpoint; students who were already a little sketchy about a feeling of belonging prior to the project were

made more so by the newness and challenge of the MBL and the science, while students who were feeling a good sense of belonging were either strengthened or only marginally disaffected.

There were five significant correlations between attendance and the knowledge measures. *Absences Project* strongly correlates with  $\Delta T$ ,  $r(70) = .33$ ,  $p < .01$  and *PostTest*,  $r(87) = -.24$ ,  $p < .05$ . The correlation with  $\Delta T$  is not surprising, since there was also an association with *Completeness  $\Delta T$* , as noted above; that correlation is positive because fewer absences for a student corresponds with a lower temperature drop for their insulating device. *Absences ELabBook* strongly correlates with these same measures, and also with  $\Delta Test$ . The correlations with  $\Delta T$  and *PostTest* are stronger:  $r(70) = .42$ ,  $p < .001$  and  $r(86) = -.26$ ,  $p < .05$ , respectively. However, there is an additional correlation with  $\Delta Test$ ,  $r(78) = -.29$ ,  $p < .01$ , which indicates that more absences during the ELabBook block of time is linked with a decrease in test score. Consistent with findings reported earlier in Table 15 of a positive relationship between ELabBook overall score and  $\Delta Test$ , this affirms the ability of the MBL to positively impact knowledge growth for all students in this study. As for the other relationships with attendance that were discovered, the implications are that students who had more unexcused absences also had a higher temperature drop in their project design, meaning their design was less efficacious. Students who had more unexcused absences also scored lower on the PostTest. Based on these findings, the motivational effect of attendance will be further explored in the regression models for *PostTest* and  $\Delta T$ .

Comparisons regarding feelings of potency were performed between the insulating device project and a science fair project that occurred a little earlier in the school year because both

were voluntary efforts for the students that involved more effort than the typical science assignment. The calculations indicate a significant but weaker correlation between the pre- and post- measures of completeness than were indicated for the other motivational variables, with  $r(96) = .31$ . There is also significant difference in the degree of mean percentage of completeness between the two; 74% of the students created an insulating device, while only 46% completed a science fair project. Because these results are different than what was found with the other variables, a further exploration of the data is helpful to shed some light on the nature of the difference.

Table 19 shows a frequency comparison between the completeness of the science fair and insulating device projects. There were 104 students who participated at one time or another in the thermodynamics unit, and eight students who transferred into or out of the class prior to the insulating device project, and thus did not have an opportunity to elect to complete both projects.

Table 19

*Contingency Table for Comparison of Completeness*

		Completeness $\Delta T$		Total
		Not Complete	Complete	
Completeness Science Fair	Not Complete	20	32	52
	Complete	5	39	44
	Total	25	71	96

For the data in Table 19, McNemar's  $\chi^2(1, N=96) = 19.7, p < .001$ , using the method suggested by García-Granero (2011) and based on Newcombe (1998). This indicates a significant improvement in completion of the insulating device than the science fair, and that this



was a result of students who did not engage in the science fair choosing to engage in the construction of the insulating device. This suggests an enhanced feeling of potency among all students for doing science after the thermodynamics unit than before. It also opens the door for attributing some of that enhanced participation to the cooperative and competitive aspects of the insulating device design, but as noted in previous chapters there is not a definitive measurement for that effect. In some sense, an enhanced cooperative and/or competitive aspect does not diminish a greater feeling of potency on the part of the students. Since the assignment was essentially voluntary rather than mandatory, a student who did not believe they could succeed even with cooperation or contribute to the competition could still choose to opt out.

There were four significant correlations between completeness or word count and the knowledge measures. This does not include the trivial connections between *Completeness  $\Delta T$*  and  *$\Delta T$  or  $\Delta T_1$* . *Completeness  $\Delta T$*  is significantly correlated with *PostTest*,  $r(85) = .33$ ,  $p < .01$ . *Words ELabBook* is significantly correlated with *PostTest*,  $r(84) = .46$ ,  $p < .001$ ; with  *$\Delta T_1$* ,  $r(70) = -.25$ ,  $p < .05$ ; and with  *$\Delta T$* ,  $r(70) = -.23$ ,  $p < .05$ . The relationships they both have with *PostTest* shows another perspective on a positive connection between the three major aspects of the study: the technology-supported knowledge supported by the MBL software, the experimental knowledge displayed through the insulating device, and the theoretical knowledge displayed through the test.

Table 20 provides a summary of the results of the three step analysis of each construct described earlier: stability across all motivation measures, change across the course of the

project, and whether the measure will be involved in regression analyses to confirm the Basic Model.

Table 20

*Summary of Relationships of Motivational Constructs*

Construct and Measures	Stable?	Change?	<i>PostTest</i> Regression?	$\Delta T$ Regression?
Competence				
<i>Self-Efficacy</i>	Yes	No	Science (+)	Science (-)
Usefulness				
<i>Intrinsic Value</i>	Yes	Science (-)	Computer (+)	No
Optimism				
<i>Anxiety</i>	Yes	No	No	No
<i>Self-Regulation</i>	Yes	No	No	No
Belonging				
<i>Attendance Project</i>	Yes	Yes (-)	Yes (+)	Yes (+)
<i>Attendance ELabBook</i>	Yes	Yes (-)	Yes (+)	Yes (+)
Potency				
<i>Completeness</i>	Yes	Yes (+)	Yes (+)	n/a
<i>Word Count</i>	n/a	n/a	Yes (+)	Yes (-)

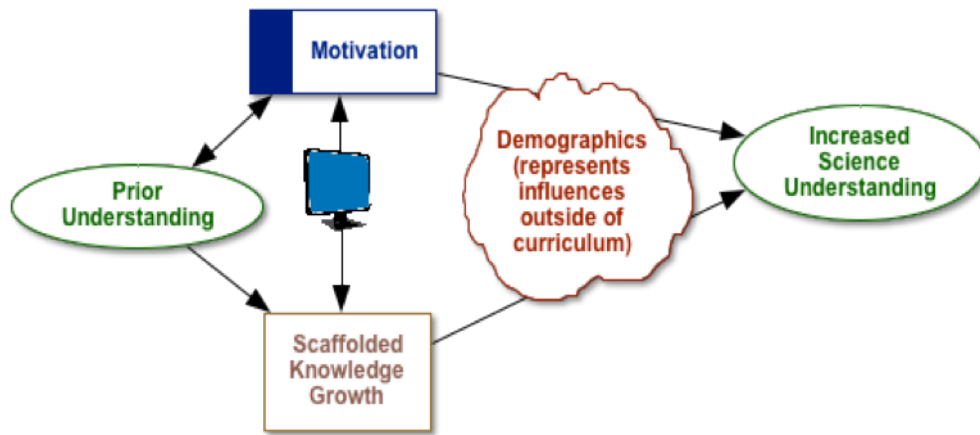
(+) or (-) indicates whether the relationship is proportional or inverse

Based on this summary, one may conclude the following about the motivation variables:

- The variables measure constructs that form a stable representation of motivation;
- For all students, feelings of potency increased across the project, while feelings of usefulness of science and belonging decreased; this suggests that motivation as a whole decreased as a result of MBL use;
- Feelings of competence in science, belonging, and potency positively affected or were positively affected by the science knowledge as demonstrated by the performance of the insulating device; and
- Feelings of competence in science, usefulness of computer use, belonging, and potency affected or were positively affected by science knowledge as demonstrated on the PostTest.

### *Regression Model for Science Understanding*

The Basic Model proposed for increasing science understanding as noted in previous chapters and portrayed again in Figure 19 is as follows: Prior Understanding + Motivation + Scaffolded Knowledge Growth = Science Understanding, with a check for effects from demographic variables *Race*, *Gender*, and *Class*.



*Figure 19: Basic model for increased science understanding*

Two regression models for predicting science understanding from these antecedents were constructed; one for science understanding as demonstrated on *PostTest*, the other as demonstrated by  $\Delta T$ . Ideally, the predictor variables will be the same for both models, if both types of outcomes represent the same types of knowledge. However, if the models are different, it may be because the outcomes represent different types of knowledge. The models will be compared to determine the influence of prior understanding (pu), motivation (m), scaffolding and knowledge growth from MBL experimentation (skg), and any effects of the demographic variables (d).

Since regression models are intended to be more confirmatory than exploratory, an informed choice of predictor variables is needed. The choice of whether to include a variable in these models are based upon on the two-tailed significance of correlations between that variable and the outcome measure of interest, either *PostTest* or  $\Delta T$ . Because it is important that predictor variables in a multiple regression not be collinear, some variables with obvious codependencies were ruled out. For example, the total ElabBook score was not used so that each of the ElabBook section scores corresponding to scaffolded knowledge growth could be included; the same is true for the pop quiz.  $\Delta Test$  was not used because it has an obvious relationship with *PostTest*. Among measures of prior understanding, whichever of *PreTest* or *MEAP* had a stronger correlation to the outcome measure was used.  $\Delta T$  and  $\Delta T_1$  were both included because chronologically, the students constructed and tested their insulating devices before taking the posttest.

The models were based upon a multiple regression method outlined by Field (2012). Field suggests using blocks of variables in a regression, with one block of variables that are being confirmed as significant predictors being directly entered into the model, and subsequent blocks with variables that are explored as predictors being entered stepwise. For the regression analyses in this report, there were two blocks of variables. The first block consisted of variables that were strongly correlated with the measure of science understanding,  $p < .01$ . The second block contained variables that were more weakly correlated with the measure of science understanding,  $p < .05$ . The inclusion criterion for the stepwise entry is  $p < .05$ , and the exclusion criterion is  $p < .10$ .

As stepwise regression has come into criticism for inflated  $R^2$  values (Judd, McClelland and Ryan, 2008), in order to confirm the veracity of the findings another hierarchical regression is performed using variables that were included from the second block or should not have been excluded from the first block. The ones that were stronger predictors ( $p < .05$ ) were directly entered as one block, and the ones that were weaker predictors ( $p < .10$ ) were entered stepwise, with the same criteria for inclusion and removal as before. The variables that remained after this second calculation were finalized as predictors for the model.

#### *Regression Model for PostTest – All Students*

The regression model was determined from a multistep analysis based on the basic model. The first step of that analysis was to determine correlations between the principal outcome measure, *PostTest*, and each of the other variables representing prior understanding, motivation, scaffolded knowledge growth, and science understanding. The correlation matrix used to identify predictors for the regression model for *PostTest* was constructed from the following variables:

- *PreTest* (pu)
- $\Delta T, \Delta T_1$  (skg); these are outcome variables in a separate regression analysis, but for inclusion in this analysis they should be considered scaffolded knowledge growth variables
- The four motivational components identified in the principle components analysis (m);
- The eleven post-project motivation variables for each domain which represent self-efficacy, intrinsic value, anxiety, self-regulation, attendance, completeness, and word count (m); these would only be considered redundant with the four components if there was an even match between components and constituents;

- ELabBook section scores which are prediction, setup of axes, graph analysis, heat flow, research from other groups (ROG), principle, and conclusion (skg);
- The pop quiz heat flow item score that specifically represents understanding of complex heat flow (skg); since much of the thermodynamics focus of the CLP project was on developing a macroscopic heat flow model, the heat flow item is the only item from the pop quiz used because it is a good representative of targeted understanding since students had to have a robust conceptual understanding of heat flow to score high; and
- Demographic variables which are race, gender, and class section (d)

Table 21 shows the correlations and the blocks for each of the variables used in the regression model for PostTest.

Table 21

*Variables Used in the Multiple Regression Model for PostTest for All Students*

Block 1, entered directly	
<i>PreTest</i> (pu)	$r(60) = .573, p < .001$
<i>Heat Flow Pop Quiz</i> (skg)	$r(60) = .552, p < .001$
<i>Setup Axes ELabBook</i> (skg)	$r(60) = .550, p < .001$
<i>Conclusion ELabBook</i> (skg)	$r(60) = .519, p < .001$
<i>Graph Analysis ELabBook</i> (skg)	$r(60) = .477, p < .001$
<i>ROG ELabBook</i> (skg)	$r(60) = .471, p < .001$
<i>Heat Flow ELabBook</i> (skg)	$r(60) = .465, p < .001$
<i>Race</i> (d)	$r(60) = .463, p < .001$
<i>3<sup>rd</sup> Hour</i> (d)	$r(60) = -.431, p < .001$
<i>Principle ELabBook</i> (skg)	$r(60) = .427, p < .001$
$\Delta T$ (skg)	$r(60) = -.397, p < .01$
<i>Potency Component</i> (m)	$r(60) = .375, p < .01$
Block 2, entered stepwise	
$\Delta T_1$ (skg)	$r(60) = .469, p < .05$
Science Self-Efficacy (m)	$r(56) = .419, p < .05$
Gender (d)	$r(56) = .359, p < .05$
<i>2<sup>nd</sup> Hour</i> (d)	$r(56) = -.343, p < .05$

Analysis of the data shows that for all students, a mixture of prior understanding and scaffolding and knowledge growth based upon the ELabBook simulations and experiment caused

a significant increase in thermodynamics knowledge. There was also an effect based upon the race of the student and which of the four classes the student was enrolled. The regression model for all students is shown in Table 22 below.

Table 22

*Regression Model Predicting PostTest Score for All Students*

	b	SE b	$\beta$
$\Delta T$ (skg)	-1.18	.330	-.301**
<i>Heat Flow Pop Quiz</i> (skg)	1.49	.446	.295**
<i>Race</i> (d)	7.86	2.52	.185**
<i>Conclusion</i> (skg)	.145	.061	-.184*
<i>3<sup>rd</sup> Hour</i> (d)	-6.81	3.12	.213*
<i>PreTest</i> (pu)	.253	.132	.266†

Note:  $R^2 = .688$ , Durbin-Watson = 1.90, N=60

†p=.061, \*p<.05, \*\*p<.01

The value of  $R^2$ , .688, indicates that the model does reasonably well in accounting for the variance in *PostTest*; the Durbin-Watson test indicates that the values are independent. Tests for collinearity were clean, as none of the predictor variables had a tolerance below .63.

The positive values of b or  $\beta$  in this table indicate a positive contribution in the regression model from those variables, and a negative relationship indicates a negative contribution. The interpretation of the prediction model is that higher scores on the PostTest are predicted best when students:

- Had lower temperature drops on their insulating devices,
- Had higher scores on the heat flow item on the pop quiz,
- Were White,

- Had higher total scores on the conclusion section of the ELabBook suite of simulations and experiment,
- Were not in the 3<sup>rd</sup> hour class, and
- Also scored high on the PreTest.

The strongest predictor of students' thermodynamics understanding at the end of the project is the efficacy of their insulating device; students whose devices had a smaller temperature drop had better performing devices, which is why the relationship between  $\Delta T$  and *PostTest* is inverted. In terms of the interrelated nature of the four science learning strands described by Michaels, Shouse and Schweingruber (2008), this is a satisfying finding that connects experimental science understanding and performance with science understanding that is theory-based and represented both textually and numerically.

The next strongest predictor was the score of the heat flow question on the pop quiz, a question that was specifically designed to retest the student's understanding of the direction of heat flow in an MBL experiment that they performed, the temperature difference experiment. The relationship is positive, and also an encouraging finding that understanding of heat flow plays a significant role in improved thermodynamics understanding. This can be seen as validation of one of the central themes of the Computer as Lab Partner (CLP) research, that possessing an accurate macroscopic model of heat flow is key to deeper understanding of thermodynamics.

The third strongest predictor is *Race*. *Race* was tabulated as a dichotomous variable, and in this case White students scored higher than African-Americans. Researchers such as Rushton and Jensen (2010) have noted that there appears to consistently be a difference in the IQ and/or



cognitive ability scores of White and African-American students of about one standard deviation. A series of independent t tests to determine whether there were significant race differences for *MEAP*, *PreTest*, and *PostTest* showed that differences did exist with White students scoring higher by about 1.0, 0.8, and 0.64 standard deviations, respectively:  $t(89) = -4.00$ ,  $p < .001$  for *MEAP*,  $t(90) = -3.58$ ,  $p < .001$  for *PreTest*, and  $t(87) = -2.92$ ,  $p < .01$  for *PostTest*. This finding piques an interest in seeing whether the prediction model for all students is the same as for only African-American or White students. The number of subjects for the two samples would be too small to draw definite conclusions, but are large enough to warrant the investigation. Interestingly, a t test to look at the effect of *Race* on  $\Delta Test$  did not show a significant effect,  $t(78) = -0.65$ , n.s. This means that White students' scores did not rise significantly more than those of African-American students, which from the perspective of teaching for equitable understanding is a good thing. More will be discussed about race later in this chapter.

The fourth predictor is the sum total of all *Conclusion* scores that the students earned from their four MBL simulations and experiments. As noted in chapter four, the conclusion score is based on the “takeaway” or key point of understanding that the students were to have internalized from the simulation or experiment. All of the scaffolds built into the ELabBook simulation or experiment are designed to help students draw a scientifically accurate conclusion. The three simulations undertaken in this unit had a similar format to the conclusion section and are drawn from the earlier CLP studies: students were asked to make a comparison of the predictions and data, accurately interpret what the data were showing, and link the data with a phenomenological explanation. For the experiment, the students were asked to compare the rate of heat flow with the temperature difference between an object and its environment. Students

who better understood the “takeaway” for each MBL investigation were able to translate that understanding into increased thermodynamics understanding. For the purpose of this thesis, finding a predictor relationship between *Conclusion* and *PostTest* implicates the value of using technology for learning science. However, there are differences with respect to both *Race* and *Gender* for this variable that will be discussed later in the chapter.

The fifth predictor is whether or not the student was enrolled in the third hour class, with students who were in the class doing worse than those who were not. As discussed in chapter 4, it is not possible to ascertain whether the effect was related to a class dynamic or the reliability of the survey. However, a survey reliability issue would be more likely to also include sixth hour enrollment as a predictor since 3<sup>rd</sup> and 6<sup>th</sup> hour classes completed the same surveys at each time. Enrollment in sixth hour was excluded from the model because it did not demonstrate a significant predictive value. If there was a class dynamic at work, might there be a motivational explanation? A series of followup independent samples t-tests comparing each of the four classes in turn with the population for the eleven motivational variables (e.g., the first set of t-tests would compare second hour against third, fourth, and sixth together) showed two things: 1) the third hour class was the only class where means of all eleven motivational variables were below those of the rest of the population, and 2) *Science Intrinsic Value* was significantly lower for 3<sup>rd</sup> hour students at the end of the project,  $t(90) = 2.06, p < .05$ . If there were postinterview survey data for the third question available for all of the students in the population, it may be possible to triangulate on a more certain conclusion, but at this point a class dynamic related to motivation is the best guess for questions about survey reliability or this demographic effect. It would be tempting to be discouraged about having such a localized predictor variable in a regression

model with a hope for some generalization, but the lesson to be learned is that classroom dynamics could be intertwined in any educational classroom research, and thus need to be addressed in both data and findings.

The final predictor is *PreTest*, which is an acknowledgement that prior science knowledge plays a role in learning, as described in chapter two. The model posits a positive impact of prior understanding on learning, which is the expected relationship, but also indicates only a marginal contribution. Since the *PreTest* and *PostTest* surveys were counterbalanced, there was no direct memory effect that helped students who did well on one survey to do well on the second. However, the effect of prior understanding was not constant for all students. Figure 20 shows the relationship between *PreTest*, *PostTest*, and  $\Delta Test$ , the measured knowledge outcomes. The solid regression line indicates a positive correlation between *PostTest* and  $\Delta Test$ , as noted earlier in this chapter. However, the dotted regression line indicates a negative correlation between *PreTest* (prior

understanding) and  $\Delta Test$ . This suggests that students with lower or intermediate *PreTest* scores had a higher boost than students with higher *PreTest* scores. For example, a look at this chart will reveal that the nine students with *PreTest* scores of 40 or higher had a mixed performance; five of those students “went backwards” on the *PostTest* (as indicated by being to

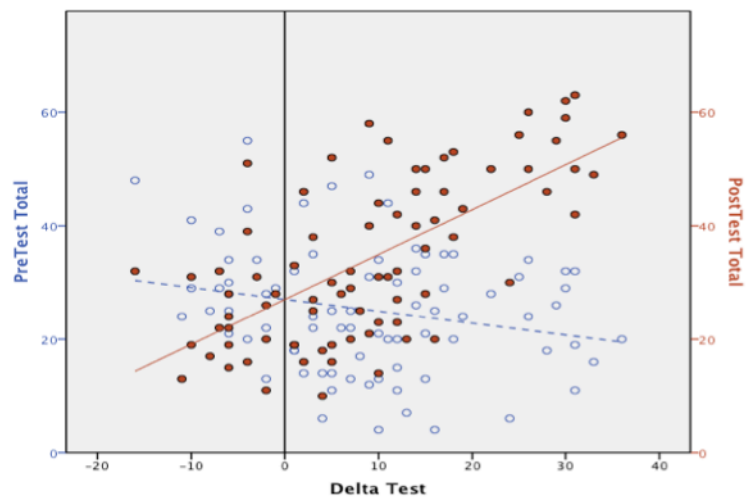


Figure 20: The relationship between prior understanding and outcome measures of knowledge

the left of the vertical reference line), and four of those students had modest gains of up to ten points. For students with a score of 20 or lower on the *PreTest*, the majority had performance gains, including the one student that had the largest  $\Delta Test$  improvement. It would be premature to say that higher levels of prior understanding can be a detriment to learning, but that is one interpretation of this data.

*Regression Model for  $\Delta T$  – All Students*

The regression model for  $\Delta T$  followed the same logic as for *PostTest*. Since *PostTest* was administered after  $\Delta T$  was completed, it was not included in the correlation matrix. Table 23 shows the correlations and blocks used in the regression model for  $\Delta T$ . The list of variables is considerably smaller than Table 21, which suggests a less robust predictor model and leaves the door open for the effects of other variables not measured.

Table 23

*Variables Used in the Multiple Regression Model for  $\Delta T$  for All Students*

Block 1, entered directly	
<i>Setup Axes ELabBook</i> (skg)	$r(69) = -.331, p < .01$
<i>Belonging Component</i> (m)	$r(69) = .318, p < .01$
Block 2, entered stepwise	
<i>Heat Flow ELabBook</i> (skg)	$r(69) = -.224, p < .05$
<i>Principle ELabBook</i> (skg)	$r(69) = -.201, p < .05$
<i>Conclusion ELabBook</i> (skg)	$r(69) = -.200, p < .05$

The relationships with the ELabBook variables are all negative because a higher ELabBook score and a lower temperature drop reflect better performance; the relationship with *Belonging* is positive because a lower percentage of days absent indicates higher motivation.

Analysis of the data shows that for all students, a mixture of motivation and scaffolding and knowledge growth based upon the ElabBook simulations and experiment contributed the most to helping students develop efficacious insulating devices. The regression model for all students is shown in Table 24 below.

Table 24

*Regression Model Predicting  $\Delta T$  for All Students*

	b	SE b	$\beta$
<i>Setup Axes ELabBook (skg)</i>	-2.14	.087	-.281*
<i>Belonging Component (m)</i>	.895	.385	.265*

Note:  $R^2 = .177$ , Durbin-Watson = 2.25, N=69

\* $p < .05$

At this point, there is confirmation that the mix of variables that predicts  $\Delta T$  is different from those that predict the more typical school science knowledge represented by *PostTest*. Unlike *PostTest*,  $\Delta T$  does not have a significant correlation with variables of prior understanding. The strongest correlations with success in the design of the insulating device have to do the skill and understanding of setting up the axes for the MBL simulations and experiments and the motivational aspect of students “being there in class,” indicating a feeling of belonging by their physical presence. However, the value of  $r^2$ , .177, suggests that the model does not account very well for the variation in  $\Delta T$ , and that there are presumably other factors at work. To wit, there may be something missing in the prediction of  $\Delta T$ .

In chapter 3, the classroom teacher cites a type of interest that the classes had in the *competition* to design the best performing insulating device. This aspect of competitiveness is something that is motivational in nature but may be ascribed to affect or another aspect of

motivation that may need to be accounted for in another way. It may make some educators uncomfortable, but the use of educational gaming with one objective being to engender competition in the service of learning has already been cited in the National Educational Technology Plan (NETP, 2010) as a cutting edge use of technology in the classroom.

The effect of the variables that do predict  $\Delta T$  may be interpreted as follows. With the first predictor, a higher combined score in the setup axes section of ELabBook predicts a lower temperature drop for the insulating device. The *Setup Axes* score reflects the students' understanding of how to set up the scales and endpoints for the real-time graph. The students would have to anticipate the temperature and time ranges that bind the data collection, and set the axes up accordingly. While there is not a specific scientific connection between anticipating how to setup axes and understanding thermodynamics, the setup axes section is perhaps more closely connected with the familiarity the students have with the software. This does have a logical link with the second predictor, the feeling of belonging, which suggests a personal sense of comfort with the unit and the technology; students who missed fewer classroom days during the unit and during the MBL segment of the unit designed devices that worked better. Together, the two predictors indicate that students who developed familiarity with the technology and the experimentation, and had a greater sense of belonging within that environment, were able to build better devices. But there is no correlation between the two variables (although they are "close,"  $p=.058$ ). If this explanation seems to leave one wanting more substance, it is worth remembering that something that was not measured by the instruments had a hand in helping students build their devices, and that competition may be all or part of that missing measure.

It should be noted that students who did not build a device would be inherently excluded from this analysis, and may bias the idea of the importance of feeling of belonging. However, a comparison between students who did and did not build a device shows no significant difference in the feeling of belonging.

It was stated earlier in this chapter that the devices built by African-American students had a lower  $\Delta T$  than those built by White students, but not significantly so. Interestingly, both of the predictor variables had significant race effects, but in opposite directions. White students had a higher *Setup Axes* score,  $t(95) = -2.21, p < .05$ , but African-American students had a stronger feeling of *Belonging*,  $t(86) = -3.29, p < .01$ .

It is arguable that a regression model for  $\Delta T_I$  may be more useful in terms of an overall predictive value for increased science understanding because any affect of an unmeasured factor such as one's desire to compete hard by redesigning the insulating device would be mitigated. It would thus be useful to construct a third model for  $\Delta T_I$  for comparison to  $\Delta T$ . If a predictor variable was in both models, it would be better instantiated as a viable predictor; if a variable was in one but not the other, it would shed some light on whether or more factors may played a role in construction of the insulating device but were subsequently overshadowed by this competitive aspect.

The regression model for  $\Delta T_I$  followed the same logic as before. Table 25 shows the correlations and blocks used in the regression model for  $\Delta T_I$ . Belonging was included in the second block even though it did not have a significant correlation with  $\Delta T_I$  because it was a

predictor variable for  $\Delta T$ . Note that the list of variables is larger than in Table 23, but the size of block one is the same, which hints at a similar level of robustness for this predictor to that of  $\Delta T$ .

Table 25

*Variables Used in the Multiple Regression Model for  $\Delta T_1$  for All Students*

Block 1, entered directly	
<i>Prediction ELabBook</i> (skg)	$r(62) = -.411, p < .001$
<i>3<sup>rd</sup> Hour</i> (d)	$r(62) = .434, p < .001$
Block 2, entered stepwise	
<i>Graph Analysis ELabBook</i> (skg)	$r(62) = -.340, p < .01$
<i>Pop Quiz Total</i> (skg)	$r(62) = -.271, p < .05$
<i>Heat Flow ELabBook</i> (skg)	$r(62) = -.262, p < .05$
<i>Conclusion ELabBook</i> (skg)	$r(62) = -.261, p < .05$
<i>Setup Axes ELabBook</i> (skg)	$r(62) = -.244, p < .05$
<i>Science Self-Efficacy, Post</i> (m)	$r(62) = -.236, p < .05$
<i>Belonging</i> (m)	$r(62) = .153, n.s.$

The relationships with the ELabBook variables and the total pop quiz score are all negative because a higher score and a lower temperature drop both reflect better performance. That the relationship with *3<sup>rd</sup> Hour* is positive means that students in that class had higher temperature drops on their initial try at the insulating device than students in other classes. The relationship with science self-efficacy is negative because a higher sense of ability reflects the better performance of a lower temperature drop. The relationship with *Belonging* is positive because a lower percentage of days absent suggests increased motivation.

The regression model for  $\Delta T_1$  is shown in Table 26.



Table 26

*Regression Model Predicting  $\Delta T_1$  for All Students*

	b	SE b	$\beta$
<i>3<sup>rd</sup> Hour</i> (d)	4.88	1.52	.361**
<i>Prediction ELabBook</i> (skg)	-.196	.066	-.331**

Note:  $R^2 = .293$ , Durbin-Watson = 1.93, N=62

\*\*p<.01

The regression model for  $\Delta T_1$  is different from that of  $\Delta T$ . The value of  $r^2$  is slightly higher than before, indicating more strength in this model than the previous one, but still leaving plenty of room for one or more unmeasured factors. As before, there is no significant relationship with variables of prior understanding.

For the initial attempt at an insulating device, one of the correlations with success in the design of the insulating device has to do with the skill and understanding developed or captured by the ability of the student to predict the outcome of the ELabBook simulations. The value of prediction in science learning was noted in chapter two, making this correlation a welcome finding because the MBL software scaffolds this role by asking students to predict prior to beginning and then asking them to draw a conclusion by looking at their prediction and comparing it to their results. The presence of *Prediction* here and of *Conclusion* in the regression model for *PostTest* is a solid validation of the value of scaffolding a process of having students make predictions and then revisit (or confront) that prediction as a way of building science understanding.

Figure 21 illustrates graphically how the prediction score was a stronger influence for  $\Delta T_1$  than for  $\Delta T$ . As before, the comparison was made with outlier data both included and removed, and the more conservative comparison with the outliers removed is shown here. The dashed regression line is

associated with *Prediction* and  $\Delta T_1$ , while the solid one is for *Prediction* and  $\Delta T$ . The ability of a student to make a more accurate prediction for the outcome of an experiment can best be seen in the initial attempt at students to design the insulating device. With successive attempts at the device being mitigated by discussion and “copying” of ideas from each other, the influence of predictive skill would be expected to decline, as indicated in the graph.

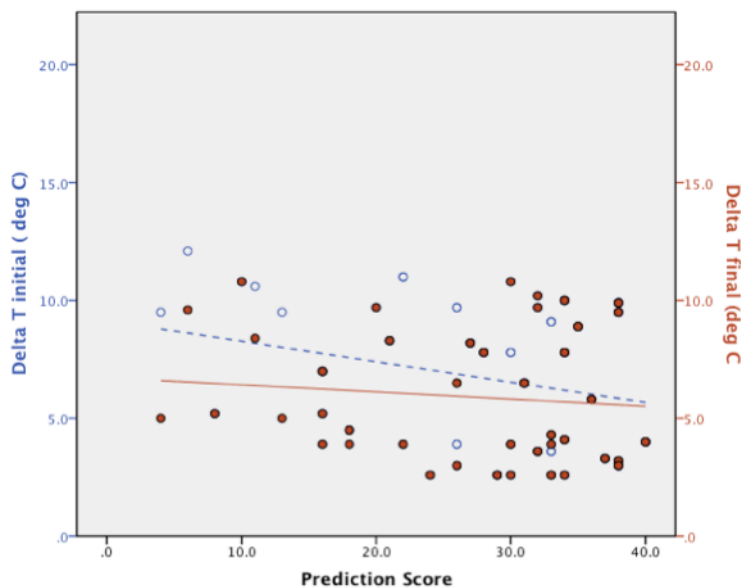


Figure 21: Relationships between prediction score and  $\Delta T_1$ ,  $\Delta T$

However, the most influential predictor for  $\Delta T_1$  is whether or not a student was in the third hour class. This is a localized effect for the study that could conflict with the desire for generalizability of the findings. This factor is also present as a factor in the regression model for *PostTest*, making it the only variable that shows up in both models; in both models, being a student in 3<sup>rd</sup> Hour was a detriment to performance. But the influence of being a student in the third hour class was not present in the regression model for  $\Delta T$ .

Figure 22 shows the relationship between  $3^{rd}$  Hour and both  $\Delta T_1$  and  $\Delta T$ . The dashed regression line is associated with  $3^{rd}$  Hour and  $\Delta T_1$ , and the solid line with  $3^{rd}$  Hour and  $\Delta T$ .

Again, comparisons were made

with outlier data identified

statistically and removed in order to

allow a cleaner interpretation, and

the more conservative comparison

with outliers removed is shown

here. The slope in the dashed line

illustrates why  $3^{rd}$  Hour predicts

$\Delta T_1$ , as there is a noticeably higher

mean value for the third hour

students than for the rest. The

figure also shows that  $3^{rd}$  Hour students were willing to redesign their insulating device, as all of

them ultimately had a temperature drop of about  $10^\circ\text{C}$  or less. That is why  $3^{rd}$  hour students had a

similar improvement in score to the rest of the students, as suggested by the fact that the slopes

of the two lines are essentially parallel, meaning the difference between the two is an offset

(change in intercept) that represents a quantum improvement in performance common to all

students. This similarity of improvement was enough to eliminate  $3^{rd}$  Hour as a predictor for  $\Delta T$ .

This willingness to improve could be explained by the unmeasured sense of competitiveness that

has been alluded to before. Later on in this chapter, the effect of class hour will be examined

more carefully.

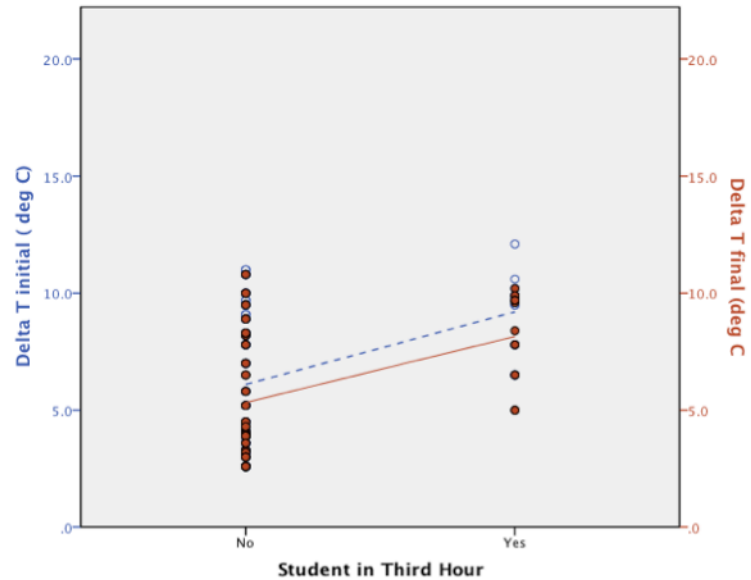


Figure 22: Relationships between  $3^{rd}$  hour and  $\Delta T_1$ ,  $\Delta T$

### *Comparison of Regression Models*

In comparing the regression models, an initial reaction may be that since the sets of predictor variables have no overlap related to prior understanding, motivation, or scaffolded knowledge growth, that the knowledge represented by *PostTest* and  $\Delta T$  may be qualitatively different. One must consider that since  $\Delta T$  was the strongest predictor of *PostTest*, in a sense the predictor variables for  $\Delta T$  are at least second-order predictor variables for *PostTest*. The predictor variables for each model are listed below in order of strongest influence:

*PostTest* ( $R^2 = .688$ )

- $\Delta T$  (skg)
- Heat Flow Pop Quiz (skg)
- Race (d)
- Conclusion (skg)
- 3<sup>rd</sup> hour (d)
- PreTest (pu)

$\Delta T_1$  ( $R^2 = .293$ )

- 3<sup>rd</sup> Hour (d)
- Prediction (skg)

$\Delta T$  ( $R^2 = .177$ )

- Setup Axes (skg)
- Belonging (m)

Recalling the basic model for increased science understanding portrayed in Figure 19, each of the three types of variables that are connected to the technology tool, *ELabBook*, are represented in one of the regression models” they are identified above by the labels (pu), (skg), and (m). Variables representing scaffolded knowledge growth are in all three models, and variables related to scaffolded knowledge growth that are embedded into the MBL software are also in all three: these are *Conclusion ELabBook*, *Prediction ELabBook*, and *Setup Axes ELabBook*. Of all five variables representing scaffolded knowledge growth, all seem to be

reasonable candidates for inclusion in the models based on the survey of the literature for how students learn science (presented in chapter two) with the exception of *Setup Axes*.

The only motivational variable present in the models was a feeling of belonging; none of the motivational indicators measured by the mMSLQ were present. The fact that most students chose to design and test an insulating device but a few didn't delineates a motivational variable, *Completeness  $\Delta T$* , that is part of the component of potency. More will be said about this in later sections addressing differences by demographic variables.

The only prior knowledge variable that was tested was *PreTest*, and it was included in the model for *PostTest*. The other prior knowledge variable, the standardized *MEAP* score was also strongly correlated with both *PreTest* and *PostTest*, but was left out of consideration for the regression because of concerns for collinearity; *MEAP* and *PreTest* are strongly correlated, thus only one of them should have been selected as a predictor variable. *PreTest* was chosen because it had a similar data type to *PostTest*; had *MEAP* been used in place of *PreTest*, it would have been included as a predictor along with the same other five variables.

Had there been no demographic variables present in the models, the data analysis would end here. Since they are present, an examination of the influence of the demographic variables of race and class hour is warranted. Since gender was expressed as an area of interest in the earlier chapters, it will be examined more closely as well. The influence of race and gender on increasing science understanding may be considered more generalizable influences, since the classrooms of interest for the generalizability of this study have diversity of race and gender. The influence of

class hour is a more localized effect, and any generalization from it will be out of concerns for validity rather than science understanding.

### *Differences by Class Hour*

The basic questions involved in this examination of differences by class hour may be heuristically derived as follows: was the third hour class more disadvantaged at the start of the unit (prior understanding)? did the class become disadvantaged by working less hard or through some other differential effects during the project (motivation, scaffolded knowledge growth)? was the class disadvantaged at the end of the project (content knowledge)? In chapter four, when discussing the reliability of the counterbalanced thermodynamics content surveys, a question was raised about whether there was an effect on account of the third hour class. That discussion will be completed here.

A series of independent samples t-tests that isolate the third hour students from the rest of the population revealed significant differences for the following variables:

- *Prediction*, (skg),  $t(94) = 2.65$ ,  $p < .01$
- *Setup Axes*, (skg),  $t(94) = 2.75$ ,  $p < .01$
- *ROG*, (skg),  $t(94) = 2.42$ ,  $p < .05$
- *ELabBook Total*, (skg),  $t(95) = 2.09$ ,  $p < .05$
- *Science Intrinsic Value, post*, (m),  $t(90) = 2.06$ ,  $p < .05$
- $\Delta T_1$ ,  $t(70) = -2.56$ ,  $p < .05$
- $\Delta Test$ ,  $t(78) = 2.46$ ,  $p < .05$
- *PostTest*,  $t(87) = 4.42$ ,  $p < .001$

In each of these areas, the third hour class performed less well than the rest of the student population.

Absent from this list are any of the variables related to prior understanding. The third hour class had higher participation and scores on *Science Fair*, and lower scores on *MEAP* and *PreTest*, and higher absenteeism prior to the unit, but none of the comparisons were significant. Thus the third hour class did not appear to be disadvantaged at the beginning.

The third hour class consistently scored lower on measures of motivation, both the components and the individual variables, with the exception of *Science Anxiety, pre*. However, the only motivational variable that showed up with a significant difference was *Science Intrinsic Value, post*. Third hour students did register a significant decrease in science intrinsic value over the course of the project,  $t(18) = -2.21, p < .05$ . Other motivational measures such as the ElabBook word count or completeness of simulations, labs, and the pop quiz do not reveal a significant difference either. In fact, third hour students had a higher word count for ELabBook in general than the rest of the students. Motivation does offer some explanation for the poorer performance by third hour students, but is not a dominant reason.

The third hour class had fewer White and female students than the remainder of the student population, but the differences were not significant. Interestingly, the third hour class was the only one with a majority of students who were either Black or male.

There were several variables related to scaffolded knowledge growth, which corresponds to how well students understood and used different sections within the MBL technology as well as their overall facility with the MBL technology. This serves to underscore the importance of the use of the technology for learning the science content in this unit. This was a group of students that was not able to grasp the use of ELabBook, with its important learning scaffolds built in, to learn thermodynamics as well as the students in other classes. The importance of the use of this technology tool for learning can be seen in a comparison in performance between the classes.

Figure 23 shows a graphical comparison between the four classes for several different variables. For *MEAP*, the third and fourth hour classes had the lowest scores that were practically the same. For *PreTest*, the third hour class had the lowest score, but was only a little more than 3% lower than second hour. With

*ELabBook*, the scores were normalized to one-fourth of their actual value to allow them to be compared on the same scale as the other variables. The second hour class had the highest ELabBook total scores, and the third hour class the lowest. For  $\Delta T_1$ , the second hour class had the lowest temperature drop, third hour had

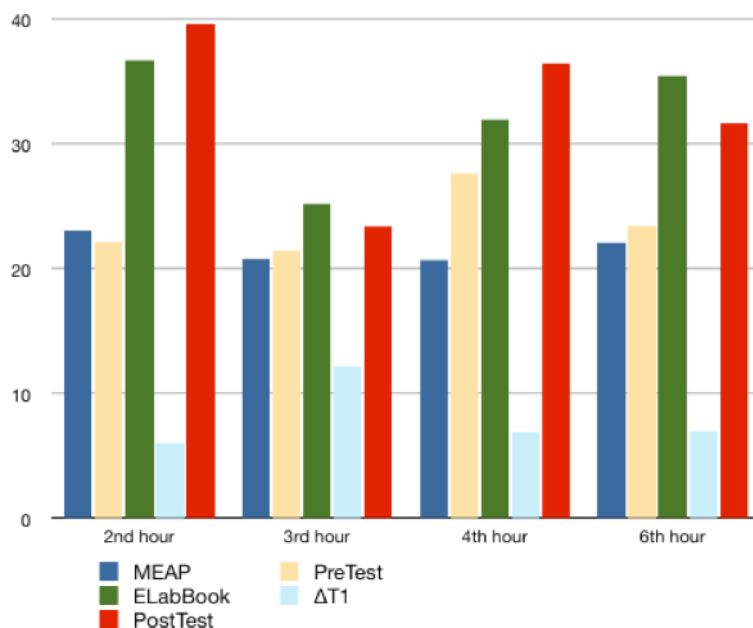


Figure 23: Comparison by class for *MEAP*, *PreTest*, *ELabBook*,  $\Delta T_1$ , *PostTest*



the highest, and the other two classes were about a degree higher than second hour. Finally, the comparison for *PostTest* shows that second hour had the highest scores, and third hour the lowest. Considering the difference between *PreTest* and *PostTest*, the third hour class only had a mean  $\Delta Test$  of 1.93, while fourth and sixth hour had respective scores of 8.82 and 8.22, and second hour students had the highest mean score at 17.5. It is hard to overlook the fact that second hour had the highest *ELabBook* and  $\Delta Test$  scores, while third hour had the lowest *ElabBook* and  $\Delta Test$  scores.

The reason that third hour students were able to do better on their values of  $\Delta T$  was because of the option of redesigning and retesting devices. 40% of the third hour students who completed a device took advantage of this option, which was more than any other class; furthermore, the only two students (one lab group) in the whole population that chose to do a third test were in the third hour. This could be considered a sign of improved motivation, but it is not linked to a clear antecedent. The presence of a class with a different majority of students than the other classes leaves open the possibility of a different social atmosphere (affect?) that was not measured by the instruments used in this study or detected by the teacher or researcher and reported in chapter three.

What seems clear is that the third hour class was not disadvantaged at the start of the unit, but became disadvantaged during the course of the unit by an inability to grasp how to use the technology to learn science that either foreshadowed or was influenced by a decrease in how they valued science from the beginning to the end of the unit. Several in the group were willing to “step up” to meet the challenge of obtaining the lowest temperature drop by redesigning and

retesting their devices. By the end of the unit, students in the third hour class demonstrated that they had not learned the material as well as students in the other classes.

### *Differences by Race and Gender*

The basic questions involved in this examination of differences by race and gender are self-evident: was one group of students advantaged at the start of the unit (prior understanding)? did one group become advantaged by working harder or through some other differential effects during the project (motivation, scaffolded knowledge growth)? was one group of students advantaged at the end of the project (content knowledge)?

With respect to prior understanding, differences by race and gender were analyzed for both *MEAP* and *PreTest*. As noted earlier, there were two groups of students within the population, the ones who designed and tested an insulating device and the ones who did not. Since it has been established that there are performance differences between these groups – the ones who demonstrated a feeling of potency by completing a device score higher on any measure than the ones who did not – these two groups will also be tracked to see if race and gender influence is the same.

Table 27 shows descriptive statistics for measures of prior understanding. Note that in all cases, the subset of students completing an insulating device had higher scores than the full population; for both *MEAP* ( $t(88) = -2.87, p < .01$ ) and *PreTest* ( $t(89) = -4.32, p < .001$ ) the increase is significant, suggesting that this subset of students was an inherently higher achieving body than the full population.

Table 27

*Descriptive Statistics for Prior Understanding Variables by Race and Gender*

	All Students				Students Completing Device			
	N	Mean ± StD	Min	Max	N	Mean ± StD	Min	Max
<i>MEAP</i> all	91	21.6 ± 6.5	5	31	67	22.9 ± 5.6	6	31
Afr-Am	41	18.8 ± 7.2	3	31	25	20.7 ± 6.2	6	31
White	50	24.0 ± 4.8	12	31	42	24.2 ± 4.9	12	31
Male	43	22.0 ± 6.2	8	31	29	23.3 ± 5.6	10	31
Female	46	21.3 ± 6.8	3	31	38	22.5 ± 5.7	6	31
<i>PreTest</i> all	92	23.9 ± 11.2	2	55 <sup>a</sup>	68	26.8 ± 10.4	6	55 <sup>a</sup>
Afr-Am	40	19.5 ± 11.1	2	55	24	23.2 ± 11.4	6	55
White	52	27.4 ± 10.0	4	48	44	28.8 ± 9.4	11	48
Male	43	21.7 ± 10.9	4	47	29	24.8 ± 10.3	6	47
Female	49	25.8 ± 11.1	2	55	39	28.3 ± 10.4	11	55

Note: Shaded data indicates a significant difference in the scores by race or gender.

<sup>a</sup> the maximum possible test score is 90

Data for both *MEAP* ( $t(89) = -4.00, p < .001$ ) and *PreTest* ( $t(90) = -3.58, p < .001$ ) showed significant differences in race that favor White students. This suggests that White students had an initial advantage over African-American students in their prior understanding. These race differences were still present but mitigated when looking at the subset of students who completed an insulating device: *MEAP* ( $t(65) = -2.57, p < .05$ ) and *PreTest* ( $t(66) = -2.19, p < .05$ ). The results show an initial achievement gap between Black and White students in this school reminiscent of that found in larger studies mentioned in chapter one such as NAEP (2005), TIMMS (2009), OECD (2010). This topic will be addressed more directly later in this chapter.

With respect to gender, there was no statistically significant difference in prior understanding; interestingly, Male students had higher scores on the standardized test while

Female students had higher scores on *PreTest*, which was thermodynamics-specific.

Table 28 provides comparative data for measures of motivation and scaffolded knowledge growth.

Table 28

*Comparative Data for Motivation and Scaffolded Knowledge Growth Variables by Race and Gender*

	All Students			Students Completing Device		
	df	t - Race	t - Gender	df	t - Race	t - Gender
<i>ElabBook</i>	96	-2.87**	-2.20*	96	n.s.	n.s.
Prediction	95	-2.10*	n.s.	95	n.s.	n.s.
Set Axes	95	-2.21*	n.s.	95	n.s.	n.s.
Graph Analysis	95	-2.71**	n.s.	95	n.s.	n.s.
Heat Flow	95	-2.17*	n.s.	95	n.s.	n.s.
ROG	95	-3.46**	-2.09*	95	-2.05*	n.s.
Principle	95	-3.25**	-2.22*	95	n.s.	n.s.
Conclusion	95	-2.68**	-2.16*	95	n.s.	n.s.
<i>Pop Quiz</i>	85	-2.52*	n.s.	63	n.s.	n.s.
Graph	83	-2.33*	n.s.	62	n.s.	n.s.
Heat Flow	84	-2.12*	n.s.	63	n.s.	n.s.
Volume	84	n.s.	n.s.	63	n.s.	n.s.
<i>Motivation</i>						
IV-SR-SE	86	n.s.	n.s.	67	n.s.	n.s.
Optimism	86	n.s.	n.s.	67	n.s.	n.s.
Belonging	86	-3.29**	n.s.	67	-3.45**	n.s.
Potency	86	-3.15**	-2.26*	67	n.s.	n.s.

\*\*\*p < .001, \*\*p < .01, \*p < .05

Table 28 shows that nearly all race and gender differences that existed for the full population of students go away in comparison to the higher achieving subgroup. The negative t values indicate a bias towards White or Female students with the exception of *Belonging*; in that

case, a lower value indicates a greater feeling of belonging. The variables that show a significant difference for both the full population and the higher achieving subgroup are the ones that will be examined more closely here because they are common to the two groups and thus identify more generalizable aspects of the importance of these variables.

As a side note, the *Potency* component that originated from the principal components analysis for motivation consisted of the variables *Word Count Total* and *Completeness  $\Delta T$* . In looking at any comparison between the full population of students and the ones who completed the insulating device, the role of *Potency* will be diminished within the latter group because the effect of *Completeness  $\Delta T$*  in the calculations will be trivial; however, by the same logic, any difference between these groups does reflect a difference in the feeling of potency. Earlier in this chapter, Table 12 compared *Completeness Science Fair* and *Completeness  $\Delta T$* , showing there was a significant increase in the number of students participating in the insulating device project as opposed to the science fair, with a suggestion of an increase in a feeling of potency across this unit. Conducting the same analysis separately for White and African-American students reveals a similar significant improvement for each; the same is true if the analysis is conducted for male and female students.

In the case of race and motivation, *Belonging* shows a bias in favor of African-American students; to wit, African-American students missed less class time during the project and during the ElabBook simulations than White students. This was even true of both the full group and the higher achieving subset prior to the project. *Belonging* was identified earlier in this chapter as one of the predictor variables in the regression model for success in completing the insulating

device. When looking at African American students alone, there was no correlation between *Belonging* and any variable related to scaffolded knowledge growth or even science understanding; however, when looking at White students, there were negative correlations with several of these variables. This motivational effect was thus neutral for African American student success, but played a role in the success of White students.

The one scaffolded knowledge growth variable that shows a significant difference for both the full group and the higher achieving subset is *ROG*, as White students had higher scores on this ElabBook section than African-American students. *ROG* was listed in Table 21 as a potential contributor to the regression model for *PostTest*, but was statistically eliminated. In order to get a higher score on this section, students needed to ask another group about their results and how they interpreted them, and summarize it within their own ELabBook writeup. Students did not have to have an interpretation of the other groups' efforts, or defend their own; they merely needed to report. There was no single MBL simulation that contributed more to the divergence of scoring on *ROG*, rather it was a cumulative effect. When looking separately at the full set of African American and White students, *ROG* was positively correlated with *Potency* as well as *PostTest*. For all African American students, *ROG* was also positively linked to *Optimism*, while for all White students *ROG* was also associated with *Belonging*,  $\Delta Test$ ,  $\Delta T_1$ , and  $\Delta T$ . For the higher achieving subset, the significant link with *PostTest* vanished for African American students, which is probably why *ROG* did not qualify for the regression model for *PostTest*; for White students, only the links with *Belonging* and *Potency* disappeared.

In the case of gender, there was no statistically significant difference in scaffolded

knowledge growth or motivation for the higher achieving subgroup.

The comparison between the full student group and the subset that completed the project is compelling in terms of race and gender for this reason: it puts the use of educational technology in a role of equalizer rather than divider. One of the intents of the National Educational Technology Plan (2010) is to allow the use of technology to aid all students when implemented in the curriculum. Looking at the full population in this study, the use of ElabBook appears to continue to divide achievement and motivation along the racial lines that already exist from prior understanding, and to create new lines of division along gender. However, looking at the subset of students who were ultimately willing to invest themselves in the completion of an insulating device, these lines largely disappear.

Table 29 shows the data for variables representing science understanding, crosstabulated for race and gender. The initial achievement gap between White and African-American students shown in Table 27 for the *PreTest* was 7.9 points for all students and 5.6 points for those who completed an insulating device. Females had an advantage over males on the *PreTest*, by 4.1 and 3.5 points respectively. By comparison with Table 29, at the *PostTest* the disparity widens to 8.7 and 8.9 for race and 9.9 and 7.6 for gender. Harkening back to the arguments related to race and IQ, one can see that if there was a tendency for White students to perform better on written tests then that propensity propagated quite nicely. But there are other results from Table 29 that swing the pendulum in the other direction as well.

Table 29

*Descriptive Statistics Related to Science Understanding, by Race and Gender*

	All Students				Students Completing Device			
	N	Mean ± StD	Min	Max	N	Mean ± StD	Min	Max
$\Delta Test$	80	9.0 ± 12.2	-16	36	66	9.1 ± 12.4	-16	36
Afr-Am	33	8.0 ± 10.2	-10	33	23	6.2 ± 9.5	-10	31
White	47	9.7 ± 13.4	-16	36	43	10.7 ± 13.6	-16	36
Male	39	7.4 ± 10.0	-10	30	29	7.0 ± 10.5	-10	30
Female	41	10.5 ± 13.9	-16	36	37	10.8 ± 13.7	-16	36
$PostTest$	89	33.2 ± 14.6	5	63 <sup>a</sup>	70	35.5 ± 14.7	10	63 <sup>a</sup>
Afr-Am	39	28.3 ± 12.8	5	58	26	29.8 ± 13.5	10	58
White	50	37.0 ± 14.9	8	63	44	38.9 ± 9.4	13	63
Male	39	28.1 ± 13.6	5	62	30	31.2 ± 14.3	10	62
Female	41	38.0 ± 14.0	11	63	40	38.8 ± 14.7	11	63
$\Delta T initial$					72	7.9°C ± 5.4	2.6°C	31.9°C
Afr-Am					26	8.0°C ± 7.6	2.6°C	31.9°C
White					46	7.8°C ± 3.8	2.6°C	18.5°C
Male					30	8.0°C ± 4.2	2.6°C	18.5°C
Female					42	7.8°C ± 6.2	2.6°C	31.9°C
$\Delta T$					72	6.4°C ± 3.5	2.6°C	31.9°C
Afr-Am					26	5.6°C ± 2.6	2.6°C	10.8°C
White					46	6.8°C ± 3.9	2.6°C	18.5°C
Male					30	7.3°C ± 4.3	2.6°C	18.5°C
Female					42	5.7°C ± 2.7	2.6°C	10.8°C

Note: Shaded data indicates a significant difference in the scores.

<sup>a</sup>The maximum possible test score is 90

There is a significant difference in the *PostTest* scores for both race and gender. For the population of all students, Whites scored significantly higher,  $t(87) = -2.92$ ,  $p < .01$ , as did Females,  $t(87) = -3.35$ ,  $p < .01$ . When considering just the subgroup of device completers, the same held true: Whites scored significantly higher ( $t(68) = -2.58$ ,  $p < .05$ ), as did Females ( $t(68)$



= -2.19,  $p < .05$ ). Since both White or Female students had a “leg up” on their African-American or Male counterparts in prior understanding by their higher *PreTest* scores, it stands to reason that this advantage would hold through to the *PostTest*.

Even though White and Female students showed larger increases in content knowledge ( $\Delta Test$  scores), there is no significant difference in these scores for either race or gender, for either the full population or the higher achieving subset of device completers. The vision for the transformative role of educational technology in the NETP (2010) is that it benefits all learners. If  $\Delta Test$  had significant differences in race, gender, or subset of students, it could be argued that the use of a computer-based learning environment in this context did not benefit all. Instead, there is evidence here that it did.

In fact, there is actually a decrease in  $\Delta Test$  among African-Americans and Males from the full population to the completers. Interestingly, this means that there were several African-American students who did not complete a device – who may have been considered educationally underserved or marginalized at the start of the unit – that showed an increase in science understanding above the class average.

In the case of  $\Delta T_1$  and  $\Delta T$ , there were no significant differences for race. African-American and White students were essentially even for the first attempt at an insulating device, but the former went on to make more refinements and as a group had a lower temperature drop. There was no significant difference in  $\Delta T_1$  for gender, but there was for  $\Delta T$  ( $t(70) = 2.04$ ,  $p < .05$ ), as Females had lower temperature differences. All of this can be best explained by looking

at the average number of trials for each race/gender profile. African-American females had the highest number at 1.3, followed by White females and African-American males at 1.2, with White males at 1.1. Because Black females had more trials and White males had fewer ones, the mean temperature drops evolved as they did from  $\Delta T_1$  to  $\Delta T$ . This is not explained well by any data from the motivation variables; it could be attributed to the missing motivational factor of competitiveness, but there is no way to know for certain. Nevertheless, the result that African-American students performed better than White students on a key measure of science understanding should not be brushed off.

### **Summary**

Near the beginning of this chapter, the principal research questions for this study were posed, followed by a list of findings relevant to each one. The answers to those questions will now be briefly reviewed in a more qualitative manner.

First, it is important to note that science understanding for all students increased as a result of this project. One of the objectives of this study was to take a technology tool that was successfully developed in classroom settings that featured groups of students for whom classroom success is generally predicted, and use it in an environment of educationally at-risk students to see if it would still be successful. This appeared to be the case.

However, the regression models for predicting the posttest scores and temperature difference values were different. This means that the composition of specific variables making up the basic model for predicting science understanding were different for each. While there can be some volatility in determining predictor variables, in this case the difference seems to be real, and may portend a delineation between the outcome variables as representatives of different types of science understanding.

Next, the features of scaffolded learning and skill development embedded in the technology that appeared to be the most important for learning were asking the students to generate a prediction for what would happen in the simulation prior to beginning, asking the students to set up the chart area for the simulation, and asking the students to draw a conclusion based on the data and make a comparison to what they had predicted. The characteristics of prediction and control fit science learning theory quite well, while the learning benefit of the setup of the chart was not as easy to map.

The motivational features that were most strongly associated with student success were a feeling of belonging as evidenced by attendance and a feeling of potency as evidenced by a higher rate of completion of an insulating device than of a science fair project, and the aggregated word count for the ELabBook notes. The more celebrated features of motivation such as feelings of competence, usefulness, and optimism that were largely measured by the mMSLQ only emerged briefly as noteworthy factors; one interesting connection that did emerge was a correlation between higher pre-project anxiety and higher scores on the posttest. There did

appear to be another motivational construct that played a role in helping students succeed which has been tentatively identified as competition but was not measured.

Race and gender effects were diminished when looking at just the group of students that completed insulating devices – completion being indicative of a feeling of potency – than the full population of students. There were some race and gender effects that both corroborated and contradicted the race and gender effects that have been seen in larger studies. White students had higher test scores from pre-project to post-project, and female students had higher test scores and designed more efficacious insulators; however, the scores were not significantly higher than their counterparts, Black students or male students. Part of the reason Whites or females had smaller average temperature drops was that they were more willing to redesign and retest their devices. The success of female students was slightly contradictory to what had been seen in the larger science studies. White students responded better to the scaffolding of the MBL environment to check the research findings of other groups, while Black students demonstrated a stronger feeling of belonging. Finally, the one class of students that underperformed also had a much different makeup by race and gender than the other classes.

In the next chapter, the implications of these findings for current and future policy and research will be examined.

## CHAPTER 6

### IMPLICATIONS AND RECOMMENDATIONS

In considering the implications of the results of this study and recommendations for the use of technology in science education, one cannot help but think of what one or two education researchers who are notable technology “skeptics” would have to say about this study were they to read it. Larry Cuban comes to mind as a self-defined technology skeptic who has recently elaborated three reasons as the basis for his disbelief: a) excessive hype that the use of technology can solve perceived problems in learning or teaching in schools, b) technology integration in schools is often introduced as an educational experiment on students who should not be experimented upon, and c) money spent on unproven technology integration is lost to other proven expenditures such as teacher development (Cuban, 2012). Another skeptical researcher who may see himself as more of a technology realist is Richard Clark, who states that “the past half-century of research, evaluation, and best practice evidence about learning from instruction has established that the choice of media does not influence learning or motivation,” (Clark. et al, 2009, p. 264) and in fact has been saying this for more than half of that half-century (Clark, 1983). His belief is that any gains in learning or motivation that have been publicized in numerous research studies over the years are more the result of effective or innovative instructional strategies that happen to employ technology than the technology itself, and further that the successful strategies have had a cognitively-focused instructional design that does not cognitively overload the learner – structure and an even pace.

From this, we are reminded that any temptation toward excessive hyperbole about the positive aspects of the technology should be set aside when reporting implications of a study for the profession, that as researchers we need to look carefully at what we attribute to technology because in the final analysis, the education of children and the professional careers of teachers are affected by the decisions made by administrators and policymakers decide from looking at published research. To wit, the “Hippocratic Oath” referred to in chapters one and five not only holds true while conducting a study, it holds true when reporting the results and suggesting the implications.

As noted in chapter one, there are three areas where the results of this study connect with the needs of the education profession in the use of technology for learning. That research agenda was charted anew by the 2010 National Educational Technology Plan, but the profession had already identified these areas where more data and research was advised. They are presented again as:

- 1) Student understanding of content, because any study of technology in a school setting has to measure this; in this case, the content area is science;
- 2) Student motivation; and
- 3) The performance of underserved students.

Richard Mayer reinforces the first two items in suggesting a need for studies within a technology-rich or technology-mediated educational environment that take some of the many constructs that have been proposed to represent motivation and “develop a testable explanation of the role of motivation in learning with media,” and then to see how learning outcomes are then

affected (Mayer, 2011, p. 305). He goes on to note that the effect of instruction within a technological environment should also be studied, a point that would not be lost on Cuban or Clark. With that in mind, it should be noted that within the statement of the classroom teacher that closed chapter three is an indication that the pedagogy and technology employed during this study would have a clear and future role within his classroom: an effect *on* instruction within a technological environment. Of course, it is outside of the scope of this study to validate that claim.

The major findings of this study may be summarized as follows based on the strength of evidence and consistency with the literature:

- 1) Multiple measures of understanding showed that on average, all groups of students including those considered to be academically “at-risk” were able to learn the science content to a level consistent with other findings for this age group and socioeconomic setting;
- 2) A research-based model that was posited for predicting increased science understanding was verified in that variables representing each of the core concepts in the model were included for different operationalizations of that understanding;
- 3) The performance of students traditionally underserved in science, Females and African-Americans, was studied and it was discovered that female students had a lower self-efficacy than males in spite of better performance on all measures of understanding, and that African-American students performed less well than Whites on all measures of understanding except the efficacy of the insulating device; it is hypothesized that the African-American students responded better on this measure because during this time the classroom environment corresponded better with a Black Cultural Ethos (including the idea of competition, further below);
- 4) Features of scaffolded learning embedded within the technology environment that were identified as most helpful to student learning included predicting the outcome of the simulation of experiment, setting up the axes or the mathematical problem space, and drawing a conclusion about a scientific principle by comparing the prediction with the findings; another feature, that

of scientific dialog with other groups in the midst of the investigation, was correlated with performance, particularly for female students; and

- 5) Motivational constructs that seemed to be most important in helping students learn were related to feelings of belonging and potency, while measurement of other constructs such as feelings of competence (self-efficacy), usefulness (intrinsic value), and optimism (anxiety and self-regulating strategies) did not indicate a significant effect; there was an additional motivational aspect related to competition that was observed to play a positive role in the performance of the students' key artifact, but no formal measurement of this conception was attempted; and
- 6) Students specifically identified both cognitive and visual (interface) aspects of the technology as both positive and negative factors in how well they were able to engage with the technology.

From both chapters one and two, several potential implications for the research literature from this study were also described: clarifying a transformative role for technology in education, identifying specific motivational constructs that affect or are affected by the use of technology rather than the broad term "motivation" which has often been alluded to in previous research involving technology integration, examining the impact of technology on societal goals such as improved science learning for all students and especially for at-risk students such as African-Americans or Females (in science classrooms), and identifying features of scaffolded learning related to making sense of science or understanding science process embedded into the technology that make a difference in classroom learning. It is also hoped that researchers seeking to develop strategy or research projects for programs such as ITEST (National Science Foundation, 2012) that explores how to help K-12 teachers connect engineering problem-solving with deep science understanding in the classroom will be helped by seeing how that connection was made in this study.



Those implications and ensuing recommendations for further study will be addressed in this chapter.

### *Science Learning for All*

In chapter five, it is shown that all of the important student groupings showed on average an improvement in science understanding as a result of this unit study. The principal measure of learning across the unit was the measurement by content survey scores and it showed an average increase for the full population, each class, both genders and both races as well. While a difference in the degree of increase between races or genders was measured, it was not significant. All groups of students learned on average – Black and White, male and female – and they improved their understanding on all three of the key aspects of heat studied by virtue of the scores of  $\Delta Test$ . A second measure of improvement was also observed in the comparison of interview scores from a sample of about 25% of the full population; the scores improved for both of the questions related to science understanding.

This is a positive finding to report from a study that among other objectives sought to see what would happen when translating a technology-mediated curriculum that was successfully field tested in a more elite, suburban and homogeneous setting to a school in another part of the country with a large at-risk population, in an urban setting with a diverse population. Lynch (2000) notes that there may be “savage inequalities” (p. 131) in the quality of science facilities in schools attended by large populations of students of color, at-risk students, or students from lower socioeconomic classes. Part of the reluctance to fund and equip such facilities may come from a concern expressed in chapter one that the education of at-risk students should involve

basic, tried-and-true pedagogy rather than a technological environment that may involve the cutting and/or bleeding edge of teaching and learning. The results of this study shows that the cutting edge of second-generation MBL technology can help all students learn, but don't go far enough to explain why. For example, Mutegi (2011) suggests that a socially transformative curriculum will make a difference in the science achievement of African-American students: a question for future research is what type of computer based learning environment is the best fit for that curriculum.

Data from a different measurement of science understanding in underserved students in this population supports an important finding: African-American students and female students did better than their counterparts in the performance of their insulating device. While it may be statistically awkward to say, one can accept that African-American students actually outperformed White students in the performance of the insulating device even though statistically the two groups were the same (the former being numerically a little better): if the one group seems to do worse on several other measures but “rises” to equal standing in an important measure, they were able to overcome some sort of disadvantage. This was the case in this study, as African-Americans had significantly lower performance on the semester grade and all the tests, standardized and other, yet had the success with the insulating devices. This contrasts with reports such as that of the Nations' Report Card (NAEP, 2005) that show a significant gap in science achievement between Black and White eighth grade students when based on written tests. In fact, an achievement gap on written tests was also found in this study. However, the success of the African-Americans does support research that finds that such students show improved achievement when “the instructional conditions incorporated communalism, verve,

and movement” (Parsons, Travis and Simpson, 2005). Out of the entirety of the thermodynamics unit, the segment where the students tested and redesigned and retested their devices had the most discussion, the most energy, and the greatest literal movement of bodies within the classroom – in fact, these were part of the ethos for success of that project. The teacher’s own words in chapter three capture the sense of excitement, imagination, and competition that ensued during this time.

Paying service to Cuban and Clark, one of the instructional reasons this ethos developed was because of an instructional decision to allow students to redo their work to their satisfaction. As a result, the quality of the their work improved. However, this was facilitated by the use of a technology that made it easy to repeat and revise, which might not be true in a more traditional setting. The use of technology did play a unique role as a cognitive partner in learning. Of course, there is a counter argument from the other side: in chapter three the suspicion was raised that some students made changes to their device without necessarily understanding why the changes would be beneficial. Unfortunately, this study did not have sufficient resolution to address the issue. One of the improvements for future studies that allow a similar strategy would be to ask the students to describe the design change and why they believe it would result in a smaller temperature drop.

After much consideration and analysis of a proposed basic model for increased science understanding, three predictor models were created from regression analysis, with different variable groupings based on the artifact demonstrating science understanding. Each of the core categories of prior knowledge, scaffolded knowledge growth, motivation, and interactions from

demographics were represented, which aligns with the research cited in chapter two and elsewhere that they should have played a role. Figures 24 and 25 show the three different operationalizations of the basic model.

The three differ from one another for one of two possible reasons. The first reason is that different types of science understanding are explained by each operationalization. Figure 24 explains a type of science understanding that

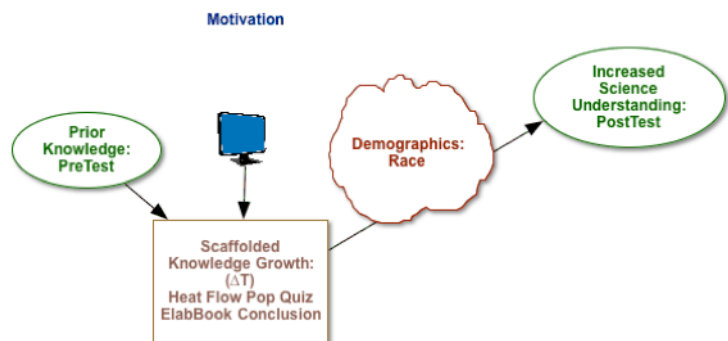


Figure 24: Basic model showing contributing variables for science understanding on PostTest

may be considered more theoretical, primarily based on students' literacy and logical reasoning skills, and contains independent variables representing scaffolded knowledge growth, prior knowledge, and the demographic of race that may have also included a class effect. While the other variables had a logical and reasonable place in the model (even race, which shows up as a covariate in many studies involving tests), the class effect did not. Much thinking in chapters four and five were devoted to illuminating the lag in knowledge growth of this one class. Could the class effect have come from the technology? As noted previously, the third hour class had less prior experience using technology both at home and at school than the others. Clark warns of the danger of cognitive overload within some technological environments, and some members of this class of students may have suffered from this. Could the class effect have come from the students not seeing where they fit – their needs, their experiences, their relevance - in the curriculum, which Mutegi (2011) would predict would happen in a group of African-American

students who could not master content, currency, context, critique, and conduct because of the limitations of the curriculum or the technology? As noted previously, the 3<sup>rd</sup> hour class had a larger mix of African-American and male students than the others.

How could either effect be measured in future studies? It is not clear how cognitive overload can be measured or sensed, but it would be worthwhile to build this type of measurement into future studies. Simplistically, one could allow students to proceed at a slower pace to reduce overload, and this would have been a good option to include in this study. Future studies like this one that involved multiple sections of the same course would benefit from checking and accounting for class effects as the unit or intervention proceeds, and doing something sooner to mitigate or eliminate those effects. In the case of African-American currency or context, both Parsons (2008) and Mutegi (2011) provide suggestions: help the students see where they, as African-American students, fit into the study of thermodynamics and/or the use of computers for learning both individually and as African-Americans. This idea was not anywhere to close to being implemented in either the CLP or ELabBook, nor in the local curriculum designed by the researcher and teacher. Both Mutegi and Johnson (2011) point out that the concept of a “one size fits all” science curriculum should be shelved once and for all in favor of culturally relevant pedagogy and curriculum; I would add that the use and design of technology for science learning should be also be culturally relevant. Researchers who attempt future studies on the use of technology in education that involve a significant or majority population of African-American students should also have discussions with other educators more familiar with Black Cultural Ethos, to strengthen how the science curriculum and/or the use of a computer-based learning environment speaks to these students.

The second and third operationalizations illustrated in Figure 25 that are related to the insulating device explain a type of understanding that is aligned more with experimental knowledge that invokes spatial skills, tactile skills, and even social skills in addition to logic.

However, the amount of variance explained by the independent variables in the second and third models is far less than the first one; clearly, one or more factors are not represented. Furthermore,

none of the motivational variables measured in this study were in those models. But there may have existed a motivational construct related to competition for which this study had no measurement. Based on observations previously described in chapter three by both the researcher and teacher, competition appeared to play a role in motivating students to design and redesign their devices. This social motivation can exist within a learning environment in several ways: competition for a higher grade than another student or lab team, competition to better one's previous performance, competition created by the instructional setting (as happened in this study), or even competition created by the technology, which was not the case in this study but which is likely to be present in gaming software (NETP 2010; Mayer, 2011). If this study were

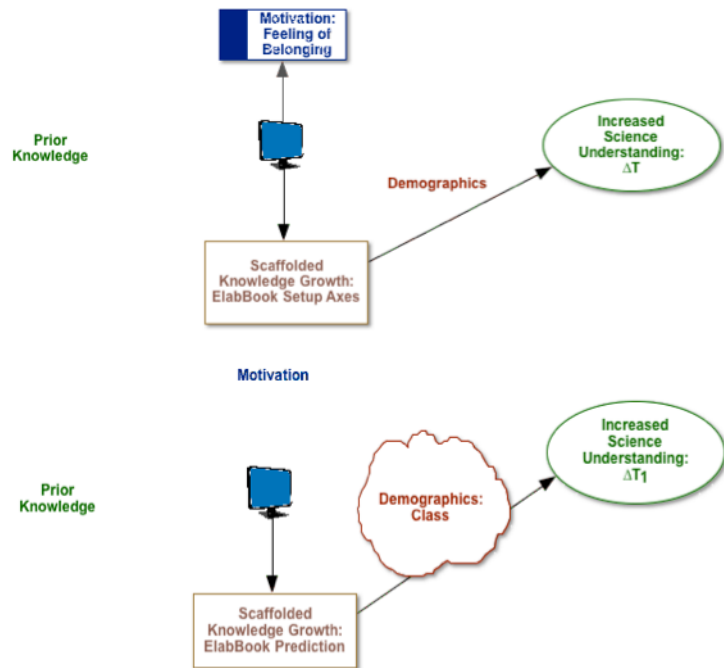


Figure 25: Basic model showing contributing variables for science understanding on insulating device

to be replicated, an additional problem space for a motivational construct related to competition should be studied and discussed, and an instrument to measure it developed and included.

### *Scaffolded Learning: Features Playing a Key Role*

Two of the variables that represent scaffolded knowledge growth in Figures 24 and 25 are the construction of the insulating device itself and the heat flow item on the pop quiz. However, it is important to remember that chronologically, they came after the completion of the ELabBook simulations and experiments. They scaffolded knowledge growth within the curriculum because they built on the students' experiences with ELabBook, which means following guidelines articulated by Quintana, et al. (2004) such as “automatically handle nonsalient, routine tasks” and “facilitate ongoing articulation and reflection during the investigation” (p. 345). However, in terms of looking at features of scaffolding embedded in the technology, they are of less interest to the findings and recommendations of the study and are thus set aside in favor of looking at the role of ELabBook.

Given that there was a high correlation between how well students did on ELabBook and the measures of thermodynamics learning, it appears that the technology played a role in helping the students learn. The features of scaffolded learning that showed the most probable cause for improving student learning were the prediction section, the setup axes section, and the conclusion section: the first for the initial attempt at a design of the insulating device, the second for the final attempt at a design, and the third for scoring higher on the post-project content survey. The first and last of these findings make good sense, as a student who is good at writing down a prediction of what will happen in an experiment will probably produce a better

experimental design on the first try, and a student who can think and write a description of a match between prediction, experimental data, and scientific theory shows a deeper understanding that will likely also come across on a written examination. Recalling chapter two, these features of the technology represent intentional scaffolding, encouraging students “to do the extra processing to link pieces of information” (Lewis, Stern & Linn, 1993, p. 48), or what Quintana, et al. (2004) identify as the use of “representations and language that bridge learners’ understanding” (p. 345), which helps them make sense of the science. These are fairly visible aspects of the science-learning strand of reflecting on scientific knowledge identified by Micheals, Shouse & Schweingruber (2008). They also serve as an example of making thinking visible, identified by Varma, Husic and Linn (2008) as a tenet of knowledge integration.

As noted in chapters three and four and illustrated in Appendix D or Stern (2000), students access each of the sections of ELabBook from a home or main card/page; the sections are either visible on that card or accessible by clicking on a button. The look and feel of the card aligns with the strategy of Quintana, et al. (2004) of “providing visual conceptual organizers to give access to functionality” (p. 345). The choice and ordering of the ELabBook sections that is determined by the teacher (or in this case, researcher and teacher) represent the strategies of “embedding expert guidance to help learners use and apply science content,” as well as “making disciplinary strategies explicit in learners’ interaction with the tool” and “restricting a complex task by setting useful boundaries for learners.” The sections also have a help facility that students can use if they are unable to understand or address what is to be done in that section, which correspond to “embedding expert guidance to indicate the rationales for scientific practices.”



This helps us to see why the sections of ELabBook can be said to scaffold knowledge growth individually or collectively.

The role played by scaffolding the proper setup of the experimental workspace does seem to be consistent with positive student performance on an experiment. The relationship between the two underscores the importance to science learning of a proper understanding of mathematical concepts related to the setup of axes, which is a recognizable aspect of the second learning strand identified by Michaels, Shouse & Schweingruber (2008) of generating scientific knowledge. As a scaffolding strategy, setup corresponds to “giving learners ‘malleable representations’ that allow them to directly manipulate representations” (Quintana, et al., 2004, p. 345) because the range of the data acquired in the simulation or experiment will change depending on the students’ choice, and there is a narrow band of choice for the setup of axes that is most reasonable and identifiable for the chart.

Could these features of scaffolded learning also be replicated in a non-technological instructional setting? or even in an instructional setting that is using a modern form of first-generation MBL (which is still alive and well in some of today’s high school and college classrooms with portable data measurement and mobile apps that did not exist in the mid-90s)? Yes they *could* – but then again they *may not*. With this second generation MBL technology and its scaffolded investigative process, students had to complete one section in order to move on to the next. There was no choice of short-circuiting the process; among other things, students had to predict and they had to conclude, in writing. The technology also adds accountability for the process, because it records the answer for the teacher to see at a time of his or her choosing. A

skeptic might be able to see it this way: if the technology takes a valuable pedagogical content-related idea and requires it as a step in a process, then any temptation to skip past it for the sake of expediency or lack of understanding by the teacher is diminished or eliminated. Schraw, Crippen & Hartley (2006) talk about expert problem-solving strategies being generated by the technology used for student learning on demand or as part of a guided process, suggesting that this could substitute for such strategies from a teacher who feels unable to provide them directly. Zhang & Quintana (2012) similarly speak of the advantage of technological scaffolding that makes an implicit activity structure explicit, so that steps important to inquiry are explicit and required in order for students to continue through the series. Recalling the previously stated regret of being unable to ascertain whether insulating device design changes were inspired by thoughtful reflection or just done because someone else said it would work, if ELabBook had been used for the device testing then this step could have been programmed in; students and teacher/researcher would not be tempted to overlook the step for the sake of expediency, and an archive of the students' written thoughts would be available even now.

Therefore, another of the lessons or tips that could be applied from this study is to make sure that an investigative process at the very least involves both a prediction and a conclusion that the students express in writing. This would undergird the larger process that Kim & Hannafin (2011) identify as supporting the development of causal reasoning. A technology that is designed to scaffold that process should have those required elements in place, and the technology should be able to record the students' writing for the teacher to read and grade later. As Clark notes, learning is best aided by a cognitively structured process, and technology is exactly suited for maintaining and archiving such a process, even if in our humanity we wish it

would allow us to skip past it. It would be tempting to also say that the investigative process should also involve finding out about research from other groups, but the evidence from this study that this piece of scaffolding contributed significantly to learning was not quite strong enough. Nevertheless, this social aspect of doing science is an area that would benefit from more attention. If discussions between students about their findings are ever part of an instructional decision, it is probably more typical for it to happen after the students have done their investigative work; ELabBook facilitates this interaction in the midst of it, which may also be a worthwhile idea to propagate.

Student comments about the technology from the post-unit interview pretty clearly indicated that there were some aspects of the technology that they liked, such as its realism (authenticity), interest, challenge, variety, and ease of use. The characteristics they disliked included the slowness of the software and its “buggy” behavior, and having to use the notes feature, and they gave a mixed review on the multimedia properties. Contemporary MBL software would probably not have the issue of slowness, as somewhere around 2000 the speed of classroom computers inexorably surpassed the threshold of computing power required for satisfactory performance. In looking carefully at the aspects mentioned most often in the interview, the positive ones were mostly cognitive while the negative ones had more to do with the interface. This dialectic between these two aspects of the software design has been discussed in the research regarding the use of gaming in education, referred to as pedagogical components and game elements (Amory, Naicker, Vincent and Adams, 1999), as fun and learning (Moreno-Ger, et al., 2008), or as design elements meant to stimulate cognition versus those meant to provide pleasure in the experience (Dondlinger, 2007). Successful video games by definition are

the ones that visually and cognitively stimulate the user. This brings out the thought that the students in this study paid attention to both the cognitive design of the technology as well as the interface (ease of use, employment of multimedia, storyline, etc.). Education technology that is meant to be transformative, a goal of the National Educational Technology Plan, is advised to engage students in both of these areas.

### *Influence of Motivation*

There was a hope on the part of this researcher that in the course of doing this study, a definitive motivational influence on learning or even just a change in motivation would be measured using the mMSLQ instrument. However, apart from a mild correlation between high anxiety and high posttest scores, nothing different was detected in the students, even when their performance should have provoked such change. For example, there was no change in the gender effect for the comparison of *Self-Efficacy Science* between the beginning and end of the project. This means that eighth-grade females began and ended this long thermodynamics project with lower science self-efficacy than males. The project they undertook had many of the hallmarks of science learning that is gender-inclusive (Rosser, 1995): it was long-term; it was holistic and novel in that the curriculum was overtly designed and described to be one that would help the students build the knowledge required to address the driving question and artifact; there was close relationship between the students and the object of study as well as between students in the class; it was set in a familiar, contemporary context that is often considered “nonscientific,” and it was noncompetitive in an interpersonal sense (even as it was in an interclass sense). The females thoroughly outperformed the males in the most important indicators of science understanding, yet an increase in their feeling of competence was not measured. This is

unfortunately not a unique finding (Jovanovic & King, 1998), as it is reminiscent of the strength of adolescent females' feelings about their science abilities reported by Eccles (1989) and Rosser (1995) and confirmed more recently by Huebner (2009). It clearly takes more than a successful (from the female students' perspective) nine-week science project to reverse those feelings. Perhaps a starting point would be to openly acknowledge the strength of their efforts as a group, an action that was not performed or even considered during the unit. Interestingly, the PISA study (2006) did not show any gender difference in self-efficacy in most countries including the United States, but the scale used in that study was very "task-specific" (p. 134) while the one used in this study was more generically geared towards science. Exploring this issue further might be as simple as taking the same items from the self-efficacy scale into an interview, asking the students to answer each item, and then asking the question "why?" each time. Brotman and Moore (2008) suggest researching the experiences of girls who are successful at science and experienced positive changes in motivation to understand how they let their achievement impact self-efficacy or anxiety, and this sort of interview would be amenable to that.

There were two motivational feelings from the list of five being examined that did seem to interact with learning. A feeling of belonging, which has a clear *social* connection to motivation, played a key motivational role in the performance of the insulating device since it was an independent variable in the predictor model. There are several things that can be said about this, most notably that White students who did not attend class and may not have felt that they fully belonged tended to do a worse job with their insulating device. This is one of those instances where a universal principle can be applied; if it is good for either at-risk or underserved students to attend school and feel a part of what is happening in the classroom both academically

and socially, then it is good for all students. It may seem trivial to put an emphasis on merely being there, but this was a school setting where students, for better or worse, exercised some leeway in whether or not to attend class. In looking at a multitude of research on technology, measuring attendance or a feeling of belonging is not generally done, but perhaps future studies should plan to measure this variable. If it is not important, it can always be eliminated from the analysis.

The other aspect of motivation that appeared to significantly change across the project even though it was not in a predictor model was a feeling of potency, as evidenced by completeness of an experimental project. There was a significant increase in the number of all students completing an insulating device versus completing a science fair project. From the teacher's perspective, both projects had similar accountability in that they were required for grading purposes but students could opt out if they wished. Sagor and Cox (2004) connect potency with locus of control, pointing out that at-risk students are good "avoiders," looking to avoid being in situations where they are threatened, confused, or lack confidence. This suggests some connection with self-efficacy was well, which is explained by the appearance of completeness (major contributor) and self-efficacy (minor contributor) together in one of the four motivational factor loadings from the principal components analysis. Clearly, the students saw something in both the insulating device project and in themselves that was absent in the science fair project that stimulated them to exercise their locus of control and complete the former. Thinking of Clark and Cuban, it could be argued that any impetus and knowledge base for the science fair stemmed from traditional science instruction, while the impetus and knowledge base for the insulating device came from a technology-mediated science instruction. But there is no

proof from this study one way or the other, as the students were never asked to explain why they chose to complete the one but not the other – or why they completed or didn't complete ELabBook simulations. As with attendance, looking at student completion of projects almost seems like a trivial measurement, but in a setting where it is normal for students to opt out of assignments, even to the point of taking a “zero” and having their grade lowered, completeness seems to play a role. A measurement of completeness of work as representative of a motivational feeling of potency is generally not indicated in research in the use of technology that I have read, but it is a measurement that perhaps should be made in future studies, especially with at-risk students who are learning with technology. The instrument should allow the researcher to connect the responses with either an internal or external locus, and further on to see if the responses also relate with self-efficacy.

## **Conclusion**

A recap of the recommendations for future research on the use of technology for science learning based on the findings of this study are as follows:

- 1) When determining the probable cause of science learning, look for contributions from the broad categories of prior knowledge, scaffolded knowledge growth and motivation, and check for interactions with demographic variables such as race, gender, and different sections of a class;
- 2) Design transformative technology environments for learning science to (at the least) scaffold prediction, setup of axes or other applicable mathematical problem space, and comparison of prediction with findings;
- 3) Show greater intentionality for integrating Black Cultural Ethos into both science curricula and technologies used as learning tools, and then study the effect of this integration on African-American students;

- 4) Show greater intentionality for helping females align their academic self-efficacy with academic performance;
- 5) Include measurements of feelings of belonging and potency in future studies of the influence of motivation on students' science learning with technology, especially with a population considered to be academically at-risk;
- 6) Further contemplate the motivational effect of both competition and an engaging user interface, which includes identifying best practices in design and implementation as well as developing usable measurement instruments; and
- 7) Further study how to scaffold scientific dialog using technology between students while in the midst of an investigation, again encompassing identification of best practices in design and implementation as well as development of usable measurement instruments.

If there is any agreement on the idea that teaching and learning *with* technology should be better than it is without, then the technology should scaffold investigative processes rather than leave them undirected, and should partner with the teacher to hold students accountable for properly and accurately predicting and concluding the investigation; the technology platforms should be fast and relatively trouble-free; the students should feel like they belong in a technology-rich classroom and have a feeling of potency such that they will complete technological artifacts based on what they have learned; and perhaps most importantly there should be no hesitation to use a successful technology with a group of students regardless of race or gender, and no hesitation in expecting them to learn with that technology given appropriate guidance and curriculum.

Keeping these recommendations in mind when devising any sort of technology-based science learning environment will help researchers and teachers move closer to achieving important national learning goals such as “To produce research findings that build knowledge about approaches, models, and interventions involving K-12-aged children and teachers that are



most likely to increase the nation's capacity and innovation in the STEM and ICT workforce of the future" (National Science Foundation, 2012).

## **APPENDIX A**

This Appendix contains the instruments used for data measurement in this study, along with any rubrics.

Secret Code: \_\_\_\_\_

Class Hour: \_\_\_\_\_

Teacher: \_\_\_\_\_

For most of these, please respond by circling the one item that best answers each question. Sometimes it will say that more than one item may be circled; in those cases, please circle as many as are true. Choose "Other" and write in an answer if it does not appear as a choice. Please answer every question to the best of your ability.

1) Does your family have a personal computer?

No      Yes      I'm not sure

If you answered yes, please write down what kind it is

\_\_\_\_\_ I'm not sure



2) Do you ever use a computer at any time besides when you are in class?

No      Yes

If you answered "No" to question 2, you may skip down to question 8.

3) Where do you use computers when you are not in class? (circle as many as are true)

my home                                      someone else's home  
at Edmonson, after school      other \_\_\_\_\_

4) How often do you use a computer?

daily      a few times a week      once in a while      hardly ever

5) What do you use a computer for? (circle as many as are true)

games      music      writing      practicing spelling, math, etc.  
reading      doing math                      programming                      other \_\_\_\_\_

6) When you use a computer, do you like to work by yourself or with someone else?

always by myself                              usually with someone else, sometimes by myself  
always with someone else      usually by myself, sometimes with someone else  
it doesn't matter

7) Have you ever taken Mr. Dake's computer class?

Yes      No      took computer class at another middle school

8) Which teachers have you had for science here at Edmonson?

6th grade: _____	didn't take science	didn't go to Edmonson
7th grade: _____	didn't take science	didn't go to Edmonson

9) Did you enter the school science fair in 5th, 6th, or 7th grade?

5th grade:	Yes	No	didn't go to Edmonson
6th grade:	Yes	No	didn't go to Edmonson
7th grade:	Yes	No	didn't go to Edmonson

10) Why have you entered the school science fair in the past? (circle as many as are true)

learn more about something	everyone in class had to	parents asked me to
win a prize	teacher asked me to	just wanted to
for extra credit in class	friend asked me to	other _____

Select the one or two most important reasons from the list above and put a star or asterisk after each one.

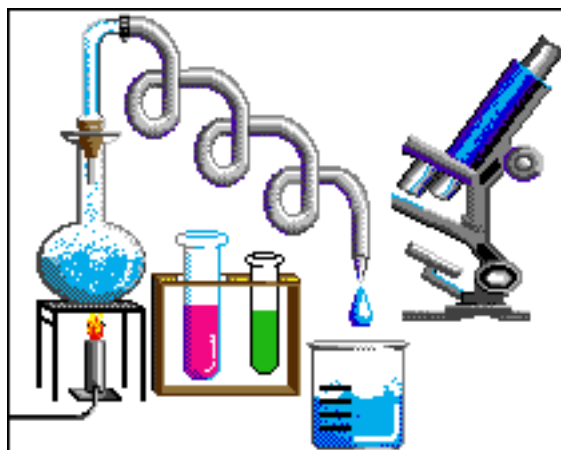
11) Have you ever learned about science outside of school?

If so, please briefly tell:  
where you learned about it

what other students learned with you

what you learned, and

who taught you.



12) How many science classes do you want to take when you're in high school?

just one   none   one every year   two or three

13) Did you like filling out this sheet?

it was cool   it was lame   it was ok

# Pre-Project Interview A

Conditions: seat the student and interviewer so that they face each other across a comfortable distance. Position a tape recorder next to both people.

Purpose: read the following paragraph to the student

As you know, next week you are going to be starting a project in your science class on the subject of thermodynamics. I am an educational researcher at the University of Michigan, and I am interested in seeing how the students in your class go about learning about thermodynamics. It is important to me that I find out a little about what you understand about thermodynamics and also about working with computers before you begin the project, because I want to see how much you will learn in the next several weeks. This interview is going to help me mark your starting point. Because of this, I would like for you to give the best answer you can for each question, even if you aren't sure that what you are saying is "right".

Instructions: review the following with the student before proceeding:

- there is no "grade" for the student's answers
- answers, comments, etc. kept in strict confidence
- the interview is being tape recorded; this is a necessary condition so that the researcher may listen to the tape in order to accurately remember what the student has said; the student will be identified on the tape by a code and not by name; a transcript of the conversation or copy of cassette tape can be made available to student, to parents or guardian, or to teacher, upon request
- the student can feel free to refuse to answer if they are feeling uncomfortable
- the interview can end at the student's discretion, but I would prefer to follow three lines of questioning and take no more than 20 minutes
- from time to time I may ask the student to explain what he/she is describing because I want to make sure I understand what they are saying

Begin: ask the student if they are ready to start the interview; when ready, start the tape recorder and verbally identify the student code

Q I have some phrases written on construction paper. I would like for you to arrange these phrases so that they make a statement that you believe to be true. You can use a phrase more than once for the sentence; just ask and I will give you a copy.

*flows around    Cold    flows into    Heat energy    and*  
*higher    Objects at    lower    stays in    Temperature*  
*Heat    flows out of    same    Cold energy*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q Do containers or wraps that help keep hot objects hot also keep cold objects cold?

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer.

Q Let's talk about computers. Think about all of the different computer software you've used, and tell me what your favorite program was. I'm going to show you a scale, and I'd like for you to rank this program on that scale.

*by far the best I've used*

*I picked this as the best, but I did think about other ones*

*the best, but it was hard to choose over another one*

*it was okay, but I've never used anything I really like*

*this is the only one I've ever used*

Follow ups: Why would you say that this was your favorite? Did you like it from the first time you tried it, or did it take a while to learn to like it? What did you like about it? What did you not like about it? Did you think it was easy to use? Do you think this program would be of value to you in learning science? Why or why not? Would you want to teach someone else how to use this program? Why or why not?

---

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School of Education  
The University of Michigan

## Pre-Project Interview B

**Conditions:** seat the student and interviewer so that they face each other across a comfortable distance. Position the tape recorder next to both people.

**Purpose:** read the following paragraph to the student

As you know, next week you are going to be starting a project in your science class on the subject of thermodynamics. I am an educational researcher at the University of Michigan, and I am interested in seeing how the students in your class go about learning about thermodynamics. It is important to me that I find out a little about what you understand about thermodynamics and also about working with computers before you begin the project, because I want to see how much you will learn in the next several weeks. This interview is going to help me mark your starting point. Because of this, I would like for you to give the best answer you can for each question, even if you aren't sure that what you are saying is "right".

**Instructions:** review the following with the student before proceeding:

- there is no "grade" for the student's answers
- answers, comments, etc. kept in strict confidence
- the interview is being tape recorded; this is a necessary condition so that the researcher may listen to the tape in order to accurately remember what the student has said; the student will be identified on the tape by a code and not by name; a transcript of the conversation or copy of cassette tape can be made available to student, to parents or guardian, or to teacher, upon request
- the student can feel free to refuse to answer if they are feeling uncomfortable
- the interview can end at the student's discretion, but I would prefer to follow four lines of questioning and take no more than 20 minutes
- from time to time I may ask the student to explain what he/she is describing because I want to make sure I understand what they are saying

**Begin:** ask the student if they are ready to start the interview; when ready, start the tape recorder and verbally identify the student code

Q I'm going to name a material, and I'd like for you to tell me if you would use it for keeping something hot, keeping something cold, both, or neither.

*aluminum foil    wool                    styrofoam*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q I have some phrases written on construction paper. I would like for you to arrange these phrases so that they make a complete sentence that you believe to be true. You can use a phrase more than once for the sentence; just ask and I will give you a copy.

*flows around    Cold                    flows into    Heat energy    and  
higher            Objects at            lower            stays in            Temperature  
Heat                flows out of    same            Cold energy*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q Let's talk about computers. Think about all of the different computer software you've used, and tell me what your favorite program was. I'm going to show you a scale, and I'd like for you to rank this program on that scale.

*by far the best I've used*

*I picked this as the best, but I did think about other ones*

*the best, but it was hard to choose over another one*

*it was okay, but I've never used anything I really like*

*this is the only one I've ever used*

Follow ups: Why would you say that this was your favorite? Did you like it from the first time you tried it, or did it take a while to learn to like it? What did you like about it? What did you not like about it? Did you think it was easy to use? Do you think this program would be of value to you in learning science? Why or why not? Would you want to teach someone else how to use this program? Why or why not?

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Secret Code: \_\_\_\_\_

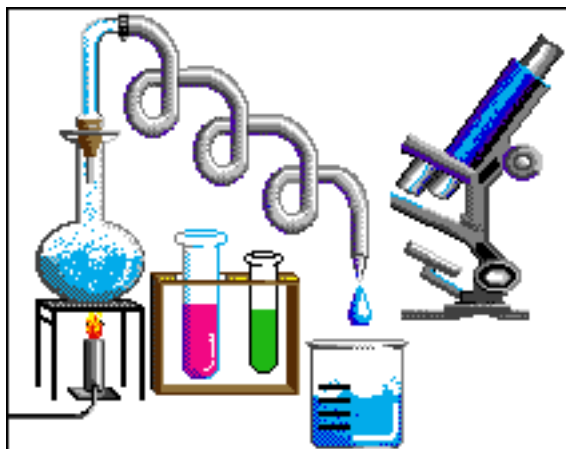
Class Hour: \_\_\_\_\_

Teacher: \_\_\_\_\_

The following statements are about the attitude of an eighth grade student towards computers and towards science class. If you think a statement is **very true** of you, circle 7; if it is **not true** at all of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you. We are very interested in your accurate answers; however, there are no right or wrong answers and your answers will be kept a secret from your name.

not at all true of me								very true of me			
1	2	3	4	5	6	7	7				
1) Compared with other students in this science class I expect to do well.					1	2	3	4	5	6	7
2) I often find that I have been reading for science class but don't know what it is all about.					1	2	3	4	5	6	7
3) I like what I am learning on the computer.					1	2	3	4	5	6	7
4) I work hard to get a good grade even if I don't like science class.					1	2	3	4	5	6	7
5) It is important for me to learn what is being taught on the computer.					1	2	3	4	5	6	7
6) I expect to do very well in this science class.					1	2	3	4	5	6	7
7) I think that what I am learning on the computer is useful for me to know.					1	2	3	4	5	6	7
8) I know that I will be able to learn the material for this science class.					1	2	3	4	5	6	7
9) I expect to do very well using the computers.					1	2	3	4	5	6	7
10) I think that what we are learning on the computer is interesting.					1	2	3	4	5	6	7
11) Compared with other students in this class, I think I know a great deal about science.					1	2	3	4	5	6	7
12) When I use the computer I think about how poorly I am doing.					1	2	3	4	5	6	7
13) I am sure I can do an excellent job on the problems and tasks assigned for this class.					1	2	3	4	5	6	7
14) I am so nervous during a science test that I cannot remember facts I have learned.					1	2	3	4	5	6	7
15) I ask myself questions to make sure I know the material I have been studying in science class.					1	2	3	4	5	6	7
16) I think I will receive a good grade in this science class.					1	2	3	4	5	6	7

	not at all true of me											very true of me
	1	2	3	4	5	6	7					7
17) I know that I will be able to learn how to use the computer for this class.	1	2	3	4	5	6	7					
18) Understanding what heat is and how it works is important to me.	1	2	3	4	5	6	7					
19) When I take a science test I think about how poorly I am doing.	1	2	3	4	5	6	7					
20) I think I will be able to use what I learn on the computer in other classes.	1	2	3	4	5	6	7					
21) I'm certain I can understand the science ideas taught in this class.	1	2	3	4	5	6	7					
22) In science class, I work on practice exercises and answer end of chapter questions even when I don't have to.	1	2	3	4	5	6	7					
23) I often choose to use computer software I will learn something from even if it requires more work.	1	2	3	4	5	6	7					
24) Compared with others in this class, I think I'm a good computer user.	1	2	3	4	5	6	7					



25) I have an uneasy, upset feeling when I take a science test.	1	2	3	4	5	6	7					
26) I think that what we are learning in this science class is interesting.	1	2	3	4	5	6	7					
27) Compared with other students in this class, I think I know a great deal about computers.	1	2	3	4	5	6	7					
28) I prefer computer work that is challenging so I can learn new things.	1	2	3	4	5	6	7					
29) Even when I do poorly on a science test I try to learn from my mistakes.	1	2	3	4	5	6	7					
30) I find that when Mr. Canty is talking I think of other things and don't really listen to what is being said.	1	2	3	4	5	6	7					
31) I prefer science class work that is challenging so I can learn new things.	1	2	3	4	5	6	7					
32) Understanding what computers are and how they work is important to me.	1	2	3	4	5	6	7					

	not at all true of me											very true of me
	1	2	3	4	5	6	7					7
33) It is important for me to learn what is being taught in this science class.	1	2	3	4	5	6	7					
34) I think I will be able to use what I learn in this science class in other classes.	1	2	3	4	5	6	7					
35) Even when I do poorly on the computer I try to learn from my mistakes.	1	2	3	4	5	6	7					
36) Even when science study materials are dull and uninteresting, I keep working until I finish.	1	2	3	4	5	6	7					
37) When I'm reading in science class I stop once in a while and go over what I have read.	1	2	3	4	5	6	7					
38) Compared with other students in this class I expect to do well in using the computers.	1	2	3	4	5	6	7					
39) I worry a great deal about science tests.	1	2	3	4	5	6	7					
40) My study skills are excellent compared with others in this science class.	1	2	3	4	5	6	7					
41) I am sure I can do an excellent job on the computer problems and tasks assigned.	1	2	3	4	5	6	7					
42) Before I begin studying for science I think about the things I will need to do to learn.	1	2	3	4	5	6	7					
43) I think I will receive a good grade on computer problems.	1	2	3	4	5	6	7					
44) I often choose to write reports on science topics I will learn something from even if they require more work.	1	2	3	4	5	6	7					
45) I worry a great deal about having to use the computer.	1	2	3	4	5	6	7					
46) I like what I am learning in this science class.	1	2	3	4	5	6	7					
47) I am so nervous when working on the computer that I cannot remember what to do.	1	2	3	4	5	6	7					
48) When the work in science class is hard I either give up or study only the easy parts.	1	2	3	4	5	6	7					
49) I have an uneasy, upset feeling when I work on the computer.	1	2	3	4	5	6	7					
50) I think that what I am learning in this science class is useful for me to know.	1	2	3	4	5	6	7					
51) Compared with others in this class, I think I'm a good science student.	1	2	3	4	5	6	7					
52) I'm certain I can understand the ideas taught in this class about how to use the computer.	1	2	3	4	5	6	7					

## Rubio Dissertation Science Content Survey A Scoring Rubric

- 1) Sean and Charlene get to decide the color for their team's soccer uniforms. The coach said the color didn't matter to her, as long as the uniforms were comfortable for wearing during the hot, humid summer months. Sean wants to get black uniforms, and Charlene wants to get white ones. If Sean and Charlene came to you and asked you which color would be more comfortable in hot weather, what would you tell them?

pick the white uniforms            it doesn't matter; either color is okay  
pick the black uniforms            pick a different color: \_\_\_\_\_

**Pick the white uniforms, w/ accompanying explanation below. (3 pts)**

**Pick the white uniforms, w/o accompanying explanation below. (1 pt)**

Explain the main reason for giving them this answer.

Objects are light-colored because they scatter or reflect light waves; they are dark-colored because they absorb light waves. When light energy is absorbed by an object, that energy is converted to heat energy. The lighter the uniform, the less heat energy it would retain and the more comfortable they would be in the summer. The lightest color that exists is white. (7 pts)

Any notion that white or light colors are cooler, or repel sun or warmth, or that black or dark colors are warmer, or attract sun or warmth. (5 pts)

Any consistent explanation - only award this if the student missed the first part. (2 pts)

Any explanation. (1 pt)

- 2) Predict what will happen if you use the materials mentioned below as a container or wrap for keeping things hot and for keeping things cold. Circle the best answer for each material under each set of conditions.

for keeping things hot:

aluminum foil	excellent	good	poor
wool	excellent	good	poor
styrofoam	excellent	good	poor

for keeping things cold:

aluminum foil	excellent	good	poor
wool	excellent	good	poor
styrofoam	excellent	good	poor

aluminum foil is poor            wool is excellent            styrofoam is good  
(2 pts for each matched set; 2 pts for correct relative ranking)

correct relative ranking for either hot or cold (1 pt)

What is the main reason for your answers?

Any reason that one can give about why a container or wrap can keep hot objects hot should also apply to why that container or wrap can keep cold objects cold. Containers or wraps are equally effective in doing either. (2 pts)

Any explanation. (1 pt)

3) Complete the following paragraph:

Temperature is . . .

Temperature is a measurement of the ability of one body to give up heat energy to another body. On a molecular level, it is the average energy of the molecules in an object. (3 pts)

Any notion that temperature is a measurement or amount of how hot or cold something is. (1 pt)

Complete the following paragraph (circle one of the choices in parentheses):

Heat and temperature are (different/the same) because . . .

Heat is an energy that "flows" between two materials which are at different temperatures. Heat is only said to exist when a temperature change exists. Therefore, based on the above definition of temperature, heat and temperature are different. (3 pts)

Any explanation accompanying "different". (1 pt)

Provide an example of an experiment or physical situation that could help explain your answer about heat and temperature.

The example chosen should reflect the notion that heat is present or felt or noticed only when there is a temperature difference. For instance, when a thermostat automatically "turns up the heat" in a room, it is transferring something between a material at a high temperature (the air in the furnace) and a material at a low temperature (the air in the room). That something is what we call "heat", but the "heat" is only felt when there is a temperature difference. If the thermostat is set for 75°C and the room temperature is 75°C, it never comes on - there is no "heat." (4 pts)

Any notion related to the "flip side" of reality, that temperature follows heat. (2 pts)

Any unamplified example. (1 pt)

4) Two eighth grade girls each decide to do an experiment. Sandra wants to measure the air temperature of the freezer in the school kitchen. Pat wants to measure her own body temperature. They go to the science lab supply room, and discover that there are two types of thermometers which can be used. Thermometer A is six inches long and contains alcohol. Its lowest marking is "92°F" and its highest marking is "106°F." Thermometer B is twelve inches long and contains mercury. Its lowest marking is "-20°C" and its highest marking is "120°C". The girls see you walking by, call you over, and ask for your advice about which thermometer to use.

Which thermometer would you suggest that Sandra use?

A      B      not sure      either one is OK

Sandra should use B (1 pt)

What is the main reason for your answer to Sandra?

Whatever temperature she expects to measure, I would tell her to pick a thermometer whose highest value is larger than the expected and whose lowest value is smaller than the expected. Sandra should expect the temperature of the freezer to be at or below the freezing point of water, 32°F or 0°C. Thermometer A cannot measure anything lower than 92°F, but Thermometer B can measure all the way down to -20°C. (4 pts)

Any notion that there is a "right" and/or a "wrong" type of thermometer for this or any other occasion. (2 pts)

Which thermometer would you suggest that Pat use?

A      B      not sure      either one is OK

Pat could use either one (1 pt)

What is the main reason for your answer to Pat?

Whatever temperature she expects to measure, I would tell her to pick a thermometer whose highest value is larger than the expected and whose lowest value is smaller than the expected. Pat should expect her body temperature to be around 98.6°F or 37°C. Thermometer A can measure anything from 92-106°F, so it can be used. Thermometer B can measure anything between -20 and 120 °C, so it can be used. (4 pts)

Any notion that there is a "right" and/or a "wrong" type of thermometer for this or any other occasion. (2 pts)

- 5) Predict whether the temperature of each of these objects is above room temperature, at room temperature, or below room temperature 24 hours after they are placed in the same room. (circle one temperature for each object)

metal frying pan	above	at	below
plastic table spoon	above	at	below
cold 20 oz. bottle of coke	above	at	below
cup of hot chocolate	above	at	below
wooden dining table	above	at	below
styrofoam cereal bowl	above	at	below
small red delicious apple	above	at	below

All objects should be at room temperature. (3 pts)

Choose two objects from the list and give the main reason for your predictions about them.

Whatever predictions that are made about the two objects should say something like this: after 24 hours, you would expect that all the objects should be at the same temperature regardless of what temperature they were at when they were put in. (7 pts)

Any notion that if one object was super-hot or super-cold when it was put in, it might not have reached room temperature yet. (3 pts)

Any consistent explanation - only award this if the student missed the first part. For example, the student rates an object a certain way and then explains why that object is rated that way. (2 pts)

Any explanation. (1 pt)

- 6) On a hot summer day, Daniel takes a gallon jug of lemonade out of the refrigerator. He fills up two glass pitchers (quart size) and two 12 oz. glasses with the lemonade, and then empties one of the cups onto a glass plate. He leaves the jug and the pitcher inside his air-conditioned kitchen. He then takes the other pitcher, the cup and the plate outside to his covered porch, and puts all of them on a picnic table. Daniel then goes into the front yard to look for his cat.

Write a "1" after the name of the item that you think will warm at the fastest rate just after Daniel leaves. Write a "2" after the name of the item that you think will warm at the second fastest rate. Continue in this manner until you come to the name of the item that you think will warm at the slowest rate, and write an "S" next to it. Put an "X" if you don't think you have been given enough information to rank that item.

cup that is outside \_\_\_\_\_ jug that is inside \_\_\_\_\_  
plate that is outside \_\_\_\_\_ pitcher that is outside \_\_\_\_\_  
pitcher that is inside \_\_\_\_\_

Choose two items from the list and give the main reason for your ranking - if you "X-ed" anything, please make something you "X-ed" one of your two choices.

cup - 2                      third-most volume, warm environment  
plate - 1                    same as cup, but more surface area  
pitcher inside - 4        same as jug but less volume  
jug inside - S             most volume, coolest environment  
pitcher outside - 3      same as other pitcher but warmer environment

Correct order, w/ accompanying explanations. (4 pts)

Correctly identifying the slowest. (1 pt)

Correctly identifying the fastest. (1 pt)

For correct explanation. (3 pts each)

For consistent explanation. (2 pts each)

For any explanation. (1 pt each)

- 7) Jean takes two cokes out of the fridge after a big, bitter cold snowstorm. She leaves one coke in her bedroom next to the radiator, and puts the other one outside underneath a snow drift. Two hours later the coke next to the radiator is warm and the coke in the snow is frozen. Could the same main idea or principle be used to describe both situations?

Yes                      No                      not sure

yes (2 pts)

Briefly describe one principle or two separate principles that explain what happened to the cokes.

The radiator is at a higher temperature than the one coke, so heat flowed from the radiator to the coke. This coke gained a lot of heat energy and is now at a higher temperature than before. The other coke is at a higher temperature than the snow, so heat flowed from the coke into the snow. This coke lost a lot of heat energy and is now at a lower temperature than before. (8 pts)

Any notion that one coke gained heat from the radiator and the other coke gained cold from the snow. (5 pts)

Any notion as above but directed only to ne coke or the other. (3 pts)

Any consistent explanation - only award this if the student missed the first part. (2 pts)

Any explanation. (1 pt)

8) Give an example of a good heat conductor. \_\_\_\_\_

(1 pt for example)

What makes the substance you picked a good heat conductor?

A good heat conductor allows heat to be transferred quickly through it. (2 pts)

Any explanation. (1 pt)

Describe a situation or experience you have seen which helped you choose this answer?

The situation or experience should describe an instance where the conductor was observed to heat quickly after being exposed to a heat source. For example, when you hold one end of a metal rod in a fire, the warmth travels to your fingers quickly and makes them uncomfortable. (2 pt)

Any unamplified situation or experience that is still applicable. (1 pt)

Give an example of a good heat insulator. \_\_\_\_\_

(1 pt for example)

What makes the substance you picked a good heat insulator?

A good heat insulator only allows heat to be transferred slowly through it. (2 pts)

Any explanation. (1 pt)

Describe a situation or experience you have seen which helped you choose this answer?

The situation or experience should describe an instance where the conductor was observed to heat slowly after being exposed to a heat source. For example, when you hold one end of a wooden rod in a fire, the end starts to burn long before your fingers feel any discomfort. (2 pts)

Any unamplified situation or experience that is still applicable. (1 pt)



- 9) Janelle and Maurice, two eighth grade science students, half-filled a beaker with water and put it on a hot plate that was turned off. They placed a thermometer in the water, and recorded the starting temperature. Then they turned the hot plate on, and watched as the water heated up, being careful to record the temperature every minute. After ten minutes, they stopped reading the thermometer.

Make a sketch of the graph that would have been made by the two students.

The sketch should show a parabolic heating curve, going from lower temp to higher temp over time. (5 pts)

Sketch shows any sort of non-linear temperature increase over time. (3 pts)

Sketch shows a temperature increase over time. (1 pt)

What is the main reason for making the sketch look like this?

The temperature of water increases slowly at first, then begins to rise more quickly after a while. (5 pts)

The temperature of the water increases over time. (2 pts)

Any explanation. (1 pt)

## Rubio Dissertation Science Content Survey B Scoring Rubric

- 1) Briefly describe a situation you have seen where something that caused light also caused warmth.

any intense light source (1 pt)

Briefly describe a situation you have seen where something that moved also caused warmth.

any friction-producing motion (1 pt)

Briefly describe a situation you have seen where something that caused electricity also caused warmth.

any electrical device that has been on for some time (1 pt)

Briefly explain one general principle which can account for all three of these situations.

Energy has been conserved in each situation: light energy converted to heat energy, kinetic energy converted to heat energy, electrical energy converted to heat energy. (7 pts)

some notion of energy conversion (4 pts)

some notion that all of the above relate to warmth or heat (1 pt)

- 2) Do containers or wraps that help keep hot objects hot also keep cold objects cold? (circle one)

yes                      no                      not sure

yes w/ some kind of accompanying explanation below (2 pts)

yes w/ no explanation below (1 pt)

What is the main reason for your answers?

The molecules of "cold" objects move slowly, and the molecules of "hot" objects move quickly. A "cold" object warms up when its molecules start to move more quickly, and a "hot" object cools down when its molecules start to move more slowly. A container or wrap keeps the slow-moving molecules of a "cold" object from being speeded up by its warm surroundings; it also keep the fast-moving molecules of a "hot" object from being slowed down by its cool surroundings. (6 pts)

some notion about keeping cold or heat in or out (4 pts)

some notion about trapping air or steam (2 pts)

any explanation (1 pt)

Describe a situation to illustrate your answer?

Any situation where the same thing is used to keep substances hot or cold will do. For example, a thermos is commonly used to keep a liquid warm (coffee, hot chocolate) or to keep it cold (lemonade, iced tea). (2 pts)

any situation where substances are only kept either hot or cold (1 pt)

- 3) Carvin went to Lake Michigan and filled a bucket with lake water. He measured the temperature of the water in the bucket and found it was 16°C. He also stuck a thermometer right into the lake, and measured the temperature of the water to be 16°C. He concluded that since these two water sources have the same temperature, they contain the same amount of heat energy. What do you think? (circle one)

Carvin is right  
I'm not sure

I think the water in the bucket has more heat energy  
I think the water in the lake has more heat energy

The water in the lake has more heat energy - w/ an accompanying explanation below. (3 pts)

The water in the lake has more heat energy - w/o an explanation below. (1 pt)

What is the main reason for your answer?

The heat energy of a substance depends on the number of molecules it has (*mass*), how "easily" those molecules can move around (we call this *specific heat*), and the speed at which those molecules are moving (*temperature*). In this case, the specific heat is the same (both samples are lake water), the temperature is the same (both samples are 16°C), but the mass is different (more mass of water in lake than in bucket). (7 pts)

Any notion that more volume = more heat energy (5 pts)

Any consistent explanation - only award this if the student missed the first part. (2 pts)

Any explanation. (1 pt)

- 4) List three different types of thermometers which you are familiar with, and the types of temperature measurements you would normally make with them.

any three thermometers (1 pt each)

Could each of these three thermometers be used to measure the temperature at which water boils in Albuquerque, New Mexico? Briefly explain your answers.

In Albuquerque, water boils at about 200°F or about 94°C. You would want to pick a thermometer that is capable of measuring this temperature. (3 pts)

A notion that one cannot use just any thermometer. (2 pts)

Any explanation. (1 pt)

Describe a general principle about measuring temperature which can account for your answers.

In order to measure the temperature of an object, you must be sure that the device you use to measure (such as a thermometer) is calibrated. This means that the device is able to accurately measure temperatures greater than and less than the object of interest. (4 pts)

A notion that some thermometers may be constructed for specific purposes. (2 pts)

Any explanation. (1 pt)

- 5) Two objects made of different materials are placed in the same room for 12 hours. One object feels colder than the other. You measure their temperatures and find they are the same. Is this possible? (circle one)

yes                  no                  not sure

yes w/ some kind of accompanying explanation below (2 pts)

yes w/ no explanation below (1 pt)

What is the main reason the objects feel different?

Both objects left alone in a room will come to about the same temperature after this amount of time. However, if one of the materials has a lower *specific heat* than the other one, then it will tend to want to gain heat energy very readily from a heat source. When you touch such an object, it will feel colder as heat energy leaves your body and enters the object. Another object in the same room with a higher *specific heat* will not want to gain heat energy so readily. When you touch this object, it feels warmer because less energy is transferred from your fingers. (8 pts)

Any notion that different materials have different heat capacities, heat transfer rates, etc. (5 pts)

Any notion that there may be local variations in a room full of objects at room temperature. (4 pts)

Any consistent explanation - only award this if the student missed the first part. (2 pts)

Any explanation. (1 pt)

- 6) Consider two identical bowls, shown below. Draw an amount of piping-hot spaghetti in the first bowl that would cool slowly. Draw an amount of piping-hot spaghetti in the second bowl that would cool more quickly. If you don't think the amount of spaghetti would affect how quickly it would cool, draw an "X" through the second bowl.

The bowl on the left should have more spaghetti than the one on the right, w/ accompanying explanation below. (4 pts)

The bowl on the left has more spaghetti, but w/o an accompanying explanation. (2 pts)

A confused answer, such as an X through the second bowl but dissimilar amounts in the two bowls. (1 pt)

Describe a general principle about the rate of cooling which can account for your answer.

If you have two objects made of the same material which start out at the same temperature, if one object has a larger volume it will cool more slowly because the "extra" material acts as "extra" insulation to keep the heat from flowing out. The converse is also acceptable. (4 pts)

Any notion that more "stuff" means a slower cooling rate, or the converse. (2 pts)

Any explanation. (1 pt)

Describe another example from your everyday life that follows the same principle.

Any example where two volumes of the same substance are observed to cool/warm at different rates will do. For instance, I take a fresh gallon of milk out of the refrigerator and use it to pour a small glass of milk, then I leave both of them on the kitchen counter. If I let them sit for half an hour, I notice that the glass of milk had warmed up a lot more than the gallon. (2 pts)

Any inconsistent or unamplified example. (1 pt)

- 7) Marques takes a very good cooler and some cokes from his hall closet, and puts the cokes into the cooler. He then goes to his freezer and takes out a package of "blue ice" and puts it into the cooler as well. When Marques closes up the cooler, which of the following will begin to lose heat energy? (circle as many as are appropriate)

blue ice      cokes      air inside cooler      Marques      none of these

objects that get colder will lose heat energy: cokes, air inside cooler (2 pts)

1 pt for each correct answer; subtract 1 pt for extraneous answers

When Marques closes up the cooler, which of them will begin to gain heat energy?

blue ice      cokes      air inside cooler      Marques      none of these

objects that get warmer will gain heat energy: blue ice (2 pts)

subtract 1 pt for extraneous answers

How might you prove which (if any) will gain and which (if any) will lose heat energy?

Any experimental test relating to temperature measurement over time will do. For example, one can prove which objects lose or gain by measuring their temperatures over time. If the temperature decreases, the object is getting cooler; if it increases, it is getting warmer. (6 pts)

Any experimental test relating to temperature measurement. (4 pts)

Any notion of replicating the problem statement as an experiment. (2 pts)

Any explanation. (1 pt)

- 8) Suppose that you were to go with your family and some friends on an overnight camping trip during the summer. That night, you all decide to build a hot campfire for roasting marshmallows. After the fire is built, your cousin comes to you holding a long, pointy iron rod and a long, pointy wooden rod and asks which one you would like to hold to stick into the fire. Which rod would you like to use?

either one is okay    the metal rod    the wooden rod    not sure

The wooden rod, w/ accompanying explanation below. (3 pts)

The wooden rod, w/o an explanation. (1 pt)

What is the main reason for your answer?

Metal is a poor heat insulator and a good heat conductor (just as it is for electricity). The metal rod would warm up more quickly in the fire than the wooden one while I was roasting my marshmallows. It could warm up so fast it could make my hand uncomfortably warm or even burn me before my marshmallows got warm enough to eat. (7 pts)

Mentioning or implying that the metal would heat up quicker than the wood. (5 pts)

Any consistent explanation, such as "the wood would burn up and thus be of little value" - only award this if the student missed the first part. (2 pts)

Any explanation. (1 pt)

- 9) The following graph shows the temperature change as an amount of hot water cools to room temperature. Use this graph to answer the following questions:

How long did it take the water to cool from 45°C to 30°C?

It was about 45°C at about 20 minutes, and 30°C at 60 minutes. Therefore, it took about 40 minutes. (4 pts)

At what time did the water temperature reach 25°C?

It reached 25°C at about 110-130 minutes. (2 pts)

It reached 25°C at about 100-140 minutes. (1 pt)

After cooling for 40 minutes, what was the temperature of the water?

After cooling for 40 minutes, it was about 35-37°C. (2 pts)

After cooling for 40 minutes, it was about 34-38 °C. (1 pt)

How much did the temperature change between 40 and 60 minutes?

Between 40 and 60 minutes, it changed about 5-7°C or about 15%. (2 pts)

Between 40 and 60 minutes, it changed about 4-8°C, or the amount of change was consistent with the answers in the first and third parts, even if one of both of those answers were incorrect. (1pt)

## Rubric - PotatoesDemo simulation

### Sequence:

design experiment,required  
set axes,required  
predictions note,level 1,required,prerequisites design experiment  
graph predictions,prerequisites design experiment¬set axes,required  
run simulation,prerequisites graph predictions¬predictions note,required  
graph comparisons note,level 2,prerequisites run simulation,required  
heat flow analysis note, level 1, prerequisites graph comparisons note,required  
conclusion note,level 1,prerequisites graph comparisons note,required,onScreenWith predictions note  
principle note,prerequisites conclusion note,optional  
prototype note,level 3,prerequisites conclusion note¬principle note,onScreenWith principle note,optional  
research from other groups note,level 3,optional,prerequisites graph comparisons note  
brainstorming note,optional  
dissenting opinion note,optional,prerequisites predictions note  
plan for another experiment note,level 2,optional,prerequisites principle note¬prototype note  
reset axes,optional  
calibrate probes,notAllowed  
collect realtime data,notAllowed  
report,prerequisites run simulation¬prototype note, optional

### PotatoesDemo Question:

Which material would be best to wrap a hot potato if you want to keep it hot? The potato has been in a 200°C oven for an hour.

### Description:

Choose any two of the materials given to wrap around the hot potato. Choose a starting temperature and a room temperature. By comparing the results from several experiments, you can tell which material will best help keep the potato hot.

### Predictions:

We predict that...

The potato wrapped in paper will retain heat better or cool off slower than the unwrapped one (4 pts).

Any other answer (1 pt.)

Something we've seen or done that gives evidence for these predictions is ...

Any answer which bears witness to the prediction (3 pts).

Any other answer (1 pt.)

It supports our predictions because ...

Any answer related to how it might support the prediction (3 pts).

Any other answer (1 pt.)

Set Axes:

The graph should be set up so that one endpoint is at 200°C and the other is at something like 20°C or so (just below room temperature). The students were to have read the room temperature from a thermometer available in the classroom. Generally, room temps varied from about 21°C in the morning to 26-27°C in the afternoon (2 pts for top endpoint, 3 pts for bottom endpoint).

Graph Analysis:

Our data showed that \_\_\_ cooled fastest in the first part of the experiment.

The correct answer - this should be obvious from the graph (4 pts).

Any other answer (1 pt.)

Our graph shows this because...

Any answer which talks about the graph for the one material dropping quicker or faster or more, or for the other material dropping slower, or less (3 pts).

Any other answer (1 pt.)

Our data showed that \_\_\_ cooled to room temperature first.

Again, there should only be one answer for this, and it should match the first answer given above under " \_\_\_ cooled fastest." (3 pts).

Any other answer (1 pt.)

Heat Flow Analysis:

At the beginning of the experiment, heat energy flowed faster out of ...

The potato wrapped in the "correct" material noted in the Graph Analysis (5 pts).

An answer consistent with the Graph Analysis (2 pts).

Any other answer (1 pt.)

This is because ...

The unwrapped potato has nothing to help retain or keep the heat in. The paper wrapping help retain or keep heat in. The paper insulates the potato. (5 pts).

Any other answer (1 pt.)



Conclusions:

Our graph predictions and our data were (alike/different) in the following ways...

A correct appraisal, such as "alike/we predicted that the potato with material x would be kept warmer longer than the potato with material y, and this is what happened." Also, a correct comparison of the predicted and simulated graphs (6 pts).

Just correctly saying "alike" or "different" (4 pts).

A partially correct comparison of the predicted and simulated graphs (3 pts).

Any other answer (1 pt.)

We found that \_\_\_ was better for keeping potatoes hot than \_\_\_.

The correct answer (8 pts).

Any other answer (1 pt.)

This is because...

Something reasonable along the lines that either the "correct" material kept the heat in the potato better or that the "other" material allowed more heat to flow out of the potato (6 pts).

Same idea but confused heat and temperature. (3 pts)

Any other answer (1 pt.)

## Rubric - Potatoes simulation

### Sequence:

design experiment,required  
set axes,required  
predictions note,level 1,required,prerequisites design experiment  
graph predictions,prerequisites design experiment→set axes,required  
run simulation,prerequisites graph predictions→predictions note,required  
graph analysis note,level 2,prerequisites run simulation,required  
heat flow analysis note,level 1,prerequisites graph analysis note,required  
research from other groups note, level 1,prerequisites graph analysis note→heat flow analysis note,required  
principle note,level 3,prerequisites heat flow analysis note,required  
conclusion note,prerequisites graph analysis note,required,onScreenWith graph analysis note  
reset axes,optional  
calibrate probes,notAllowed  
collect realtime data,notAllowed

### Potatoes Question:

Which material would be best to wrap a hot potato if you want to keep it hot? The potato has been in a 200°C oven for an hour.

### Description:

<none>

### Predictions:

We predict that...

For the first simulation, anything relevant will do. Relevance includes the relative efficacy of the materials for insulating as well as the practicality of doing this simulation. For the \*second\* simulation, "relevance" only means getting the correct order for the efficacy of the materials; the pecking order (best to worst) is wool, styrofoam, paper, saran wrap, aluminum foil, nothing. (4 pts)

Any other answer (1 pt.)

Something we've seen or done that gives evidence for these predictions is ...

Any answer which bears witness to the prediction. (3 pts)

Any other answer (1 pt.)

It supports our predictions because ...

Any answer related to how it might support the prediction. (3 pts)

Any other answer (1 pt.)

Set Axes:

The graph should be set up so that one endpoint is at 200°C and the other is at something like 20°C or so (just below room temperature). The students were to have read the room temperature from a thermometer available in the classroom. Generally, room temps varied from about 21°C in the morning to 26-27°C in the afternoon (2 pts for top endpoint, 3 pts for bottom endpoint)

Graph Analysis:

Our data showed that \_\_\_ cooled fastest in the first part of the experiment.

The correct answer - this should be obvious from the graph. (3 pts)

Any other answer (1 pt.)

Our graph shows this because...

Any answer which talks about the graph for the one material dropping quicker or faster or more, or for the other material dropping slower, or less. (3 pts)

Any other answer (1 pt.)

Our data showed that \_\_\_ cooled to room temperature first.

Again, there should only be one answer for this, and it should match the first answer given above under "\_\_\_ cooled fastest." (3 pts)

Any other answer (1 pt.)

Our graph shows this because...

Any answer which talks about the curve reaching an imaginary  $y = \text{room temp}$  line, or some other way of expressing that same idea. (3 pts)

Any other answer (1 pt.)

Our simulation data showed that \_\_\_ had a temperature of ? deg C after 20 minutes, and that \_\_\_ had a temperature of ? deg C after 20 minutes.

The correct answer - this should be obvious from the graph. (2 pts for each correct pair of answers, maximum 4 pts)

Our simulation data showed that \_\_\_\_ cooled to room temperature after ? minutes, and that \_\_\_\_ cooled to room temperature after ? minutes.

The correct answer - this should be obvious from the graph. (2 pts for each correct pair of answers, maximum 4 pts)

Heat Flow Analysis:

After taking the potato out of the oven, heat energy flowed (into/out of) the potato (from/to) \_\_\_\_

Heat energy flowed out of the potato and into the room or air. (5 pts), or

Heat energy flowed out of the potato and into the wrapping material (5 pts), or

Heat energy flowed out of the wrapping material and into the air. (5 pts)

These answers are not mutually exclusive, of course; however, if they answer the last two together, then award 10 pts.

Any other answer (1 pt.)

Research from Other Groups Note:

(go and ask another group who did a coke or potato simulation what their results were)

We got results from

Any valid group (2 pts)

They did a simulation with

Potatoes or Cokes (1 pt.)

The materials they used were

Whatever they were (1 pt for each correct)

They found that

The conclusion the other group gave them. (5 pts)

Principle Note:

A principle that describes this experiment is...

Heat energy flows faster through a good conductor than through a poor conductor.

Heat energy flows slower through a poor conductor than through a good conductor.

List: as, Cold energy, flows at the same rate, flows faster, flows slower, Heat energy, Temperature, than, through a good conductor, through a poor conductor

ELabBook automatically notes whether the principal note was correctly discerned or not. If they discerned the principle, award 10 pts.

If they tried to get the principle but were unsuccessful, award 4 pts.

Δ

-----  
Describe a situation from everyday life that could be explained with this principle.

[not assessed - no points]

### Conclusions:

Our graph predictions and our data were (alike/different) in the following ways...

A correct appraisal, such as "alike/we predicted that the potato with material x would be kept warmer longer than the potato with material y, and this is what happened." Also, a correct comparison of the predicted and simulated graphs. (6 pts)

Just correctly saying "alike" or "different." (4 pts)

Any other answer (1 pt.)

We found that \_\_\_ was better for keeping potatoes hot than \_\_\_.

The correct answer. (8 pts)

Any other answer (1 pt.)

This is because...

Something reasonable along the lines that either the "correct" material kept the heat in the potato better or that the "other" material allowed more heat to flow out of the potato. The comment should be of a physical rather than a symbolic nature. (6 pts)

Saying that one is thicker than the other. (4 pts)

A correct comment of a symbolic nature. (3 pts)

Any other answer (1 pt.)

## Rubric - Coke simulation

### Sequence:

design experiment,required  
set axes,required  
predictions note,level 2,required,prerequisites design experiment  
graph predictions,prerequisites design experiment→set axes,required  
run simulation,prerequisites graph predictions→predictions note,required  
graph analysis note,level 2,prerequisites run simulation,required  
heat flow analysis note,level 1,prerequisites graph analysis note,required  
research from other groups note, level 1,prerequisites graph analysis note→heat flow analysis note,required  
principle note,level 3,prerequisites heat flow analysis note,required  
conclusion note,prerequisites graph analysis note,required,onScreenWith graph analysis note  
reset axes,optional  
calibrate probes,notAllowed  
collect realtime data,notAllowed

### Cokes Question:

Which material would be best for wrapping around a cold can of coke if you want to keep the coke cold?  
Two cokes have been in a 2°C refrigerator for two hours, and are then taken out.

### Description:

<none>

### Predictions:

We predict that...

For the first simulation, anything relevant will do. Relevance includes the relative efficacy of the materials for insulating as well as the practicality of doing this simulation. For the \*second\* simulation, relevance only means getting the correct order for the efficacy of the materials; the pecking order (best to worst) is styrofoam, wool, paper, saran wrap, aluminum foil, nothing. (4pts)

Any other answer (1 pt.)

Something we've seen or done that gives evidence for this is ...

Any answer which bears witness to the prediction. (3 pts)

Any other answer (1 pt.)

It supports our predictions because ...

Any answer related to how it might support the prediction. (3 pts)

Any other answer (1 pt.)

Set Axes:

The graph should be set up so that one endpoint is at 0-2°C and the other is at something like 20-25°C or so (just below room temperature). The students were to have read the room temperature from a thermometer available in the classroom. Generally, room temps varied from about 21°C in the morning to 26-27°C in the afternoon. (3 pts for top endpoint, 2 pts for bottom endpoint)

Graph Analysis:

Our data showed that \_\_\_ warmed fastest in the first part of the experiment.

The correct answer - this should be obvious from the graph. (4 pts)

Any other answer (1 pt.)

Our graph shows this because...

Any answer which talks about the graph for the one material dropping quicker or faster or more, or for the other material dropping slower, or less. (3 pts)

Any other answer (1 pt.)

Our data showed that \_\_\_ warmed to room temperature first.

Again, there should only be one answer for this, and it should match the first answer given above under "\_\_\_ cooled fastest." (3 pts)

Any other answer (1 pt.)

Our graph shows this because...

Any answer which talks about the curve reaching an imaginary y=room temp line, or some other way of expressing that same idea. (3 pts)

Any other answer (1 pt.)

Our simulation data showed that \_\_\_ had a temperature of ? deg C after 20 minutes, and that \_\_\_ had a temperature of ? deg C after 20 minutes.

The correct answer - this should be obvious from the graph. (1 pt for each correct answer; also award 1 pt for getting a correct answer: minimum 2 pts, maximum 5 pts)

Attempting an answer - only award this if no points are given above (1 pt.)

Our simulation data showed that \_\_\_ warmed to room temperature after ? minutes, and that \_\_\_ cooled to room temperature after ? minutes.

The correct answer - this should be obvious from the graph. (1 pt for each correct answer; also award 1 pt for getting a correct answer: minimum 2 pts, maximum 5 pts)

Attempting an answer - only award this if no points are given above (1 pt.)

Heat Flow Analysis:

In our simulation, heat energy flowed (into/out of) the coke (from/to) \_\_\_\_

Heat energy flowed into the coke from the room or air. (5 pts), or

Heat energy flowed into the coke from the wrapping material (5 pts), or

Heat energy flowed into wrapping material from the air. (5 pts)

These answers are not mutually exclusive, of course; however, if they answer the last two together, then award 10 pts.

Any other answer (1 pt.)

Research from Other Groups Note:

(go and ask another group who did a coke or potato simulation what their results were)

We got results from

Any valid group (2 pts)

They did a simulation with

Potatoes (1 pt)

The materials they used were

Whatever they were (1 pt for each correct)

They found that

The conclusion the other group gave them. (5 pts)

Principle Note:

A principle that describes this experiment is...

Heat energy flows faster through a good conductor than through a poor conductor.

Heat energy flows slower through a poor conductor than through a good conductor.

List: as, Cold energy, flows at the same rate, flows faster, flows slower, Heat energy, Temperature, than, through a good conductor, through a poor conductor

ELabBook automatically notes whether the principal note was correctly discerned or not. If they discerned the principle, award 10 pts.

If they tried to get the principle but were unsuccessful, award 4 pts.

Δ

-----

Describe a situation from everyday life that could be explained with this principle.

[not assessed - no points]



Conclusions:

Our graph predictions and our data were (alike/different) in the following ways...

A correct appraisal, such as "alike/we predicted that the potato with material x would be kept warmer longer than the potato with material y, and this is what happened." Also, a correct comparison of the predicted and simulated graphs. (6 pts)

Just correctly saying "alike" or "different" (4 pts).

Any other answer (1 pt.)

We found that \_\_\_ was better for keeping cokes cold than \_\_\_.

The correct answer (8 pts).

Any other answer (1 pt.)

This is because...

Something reasonable (6 pts).

Saying that one is thicker than the other (4 pts).

Any other answer (1 pt.)

## Rubric - Temperature Difference Experiment

### Sequence:

design experiment,required  
predictions note,level 3,required,prerequisites design experiment, required  
set axes, prerequisites predictions note, required  
graph predictions, prerequisites predictions note, required  
collect realtime data, prerequisites graph predictions-predictions note,required  
graph analysis note, level 3, prerequisites collect realtime data, required  
heat flow analysis note, level 3, prerequisites collect realtime data, required  
research from other groups note, level 3,prerequisites collect realtime data, required  
principle note,level 1,prerequisites research from other groups note, required  
conclusion note,level 3,prerequisites principle note, required  
reset axes,optional

### $\Delta$ Temp Question:

How does the difference in volume and temperature between an object and its surroundings affect how fast the object cools (or heats)? Place a 50 ml beaker filled with 40 ml of very hot water inside a 250 ml beaker filled with 75 ml of ice/cold/tap/warm/hot water, and measure the temperature change of the water in each beaker over 10 minutes.

### Description:

<none>

### Predictions:

In our own words, we think the second law of thermodynamics says that ...

heat or heat energy flows from the warmer body to the cooler one; also, if they use a knowledge of the second law to accurately predict that the small beaker will heat up the large one, or if the system will eventually go to room temp (8 pts).

a misinterpretation of the second law, such as reversing the direction of heat flow; also using a misinterpreted second law to predict what will transpire (3 pts).

Any other answer (1 pt)

We have chosen the temperature of the water in the large beaker to be (icy/cool/room/warm/hot) at about ? deg C.

consistent choice: i.e. icy~0-10°C, cool ~10-20°C, room ~20-27°C, warm ~27-40°C, hot >40°C (2 pts)

inconsistent choice or one item missing or "I'll do it later" (1 pt.)

We predict that the "inner" liquid will (cool off/warm up) by about ? deg C after 10 minutes).

[not assessed - no points]

Set Axes:

The graph should be set up so that the two endpoints accommodate the expected temperature range. The most sensible choices are the boiling and freezing points of water. For full credit, all points of each curve should fall inside the endpoints (5pts).

Some points of each curve fall either above OR below [not both] an endpoint (2 pts).

Graph Analysis:

Our data showed that the temperature of \_\_\_\_ was ? deg C at the start of the experiment and ? deg C at the end.

The correct answer - this should be obvious from the graph. (5 pts)

Our data showed that the temperature of \_\_\_\_ was ? deg C at the start of the experiment and ? deg C at the end.

The correct answer - this should be obvious from the graph. (5 pts)

Heat Flow Analysis:

At the beginning of the experiment, heat energy ...

Heat energy flowed from the small beaker or glass into the large beaker. (5 pts)

Heat energy flowed from the small beaker or glass into the room or air. (5 pts)

Heat energy flowed (from/to) the room or air (into/out of) the large beaker. (5 pts)

Credit may also be awarded if the answer is consistent with their graph [in case something funny happened which was beyond the students' reasonable control] (5 pts).

A correct, symbolic explanation. (2 pts)

Any other answer (1 pt.)

This is because ...

Any sort of reference to the fact that the graph may be read to show this, i.e. one curve dropped/rose faster than the other rose/dropped, or that they both rose/dropped about the same amount (5 pts).

Any other answer (1 pt.)

Research from Other Groups Note:

(Talk to another group whose design was •different• from yours)

We got results from ...

Any valid group (1 pts.)

Their data showed that the temperature of \_\_\_\_ was ? deg C at the start of the experiment and ? deg C after ? minutes.

Whatever they were (1 pt for each correct)

Their data showed that the temperature of \_\_\_\_ was ? deg C at the start of the experiment and ? deg C after ? minutes.

Whatever they were (1 pt for each correct)

This information is (believable/not believable) because...

Anything that is different from some blow-off answer like "because it is" (5 pts)

A blow-off answer (1 pt).

#### Principle Note:

Construct a principle that explains how the temperature difference between an object and it's surroundings affects how fast heat energy flows. (Click the hammer)

The greater the temperature difference between objects and their surround, the faster heat energy flows

The smaller the temperature difference between objects and their surround, the slower heat energy flows

List:

ELabBook automatically notes whether the principal note was correctly discerned or not. If they discerned the principle, award 10 pts.

If they tried to get the principle but were unsuccessful, award 4 pts.

Δ

-----  
Could this principle help you in your project design?

[not assessed - no points]

#### Conclusions:

We learned that the temperature difference between an object and its surround affects how fast heat flows in the following way...

The greater the  $\Delta T$  between an object and its surround, the faster heat flows (12 pts).

Any answer (1 pt).

This affects how fast the object's temperature changes in the following way...

Something observationally based: The faster heat flows, the slower the temp changes afterwards - i.e. an inverse power relationship (4 pts).

Any answer (1 pt).

Why do you think the temperature difference affects how fast heat energy flows?

Temperature may be defined as a partial measure of how readily heat will flow out of or into an object (4 pts).

Any answer (1 pt).

Name:

Period:

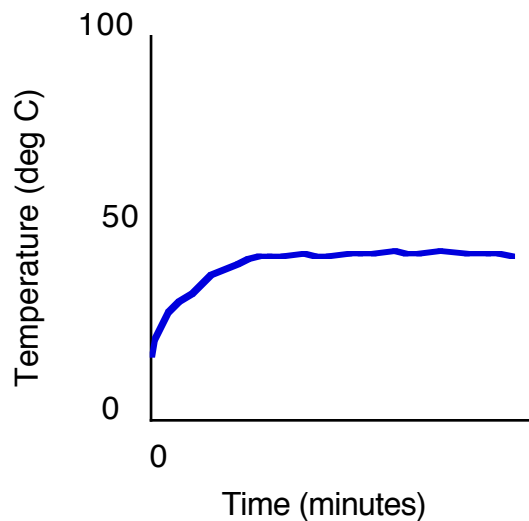
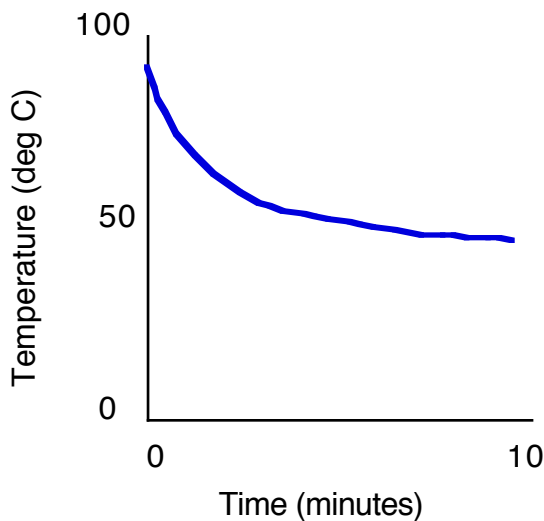
What was the temperature of the clam chowder that you measured in class with the unmarked thermometers that you calibrated a few weeks ago? Go ahead and look in your class folders if you need to.

the maximum temp the unmarked thermometers can measure is about  $50^{\circ}\text{C}$ ; the temp should be between room temp ( $\sim 25^{\circ}\text{C}$ ) and the maximum - aka  $\sim 75^{\circ}\text{F}$  -  $120^{\circ}\text{F}$  (2 pts)

for giving a value that is too high or too low (1 pt)

for giving a potentially reasonable value without the units (1 pt)

Think about the temperature difference experiment that we did the past week. On the left, sketch the graph of temperature vs. time for the small beaker; on the right, sketch the same graph for the large beaker.



for each plot:

drawing the correct curve (3 pts)

drawing a correct curve but with an incorrect segment (2 pts)

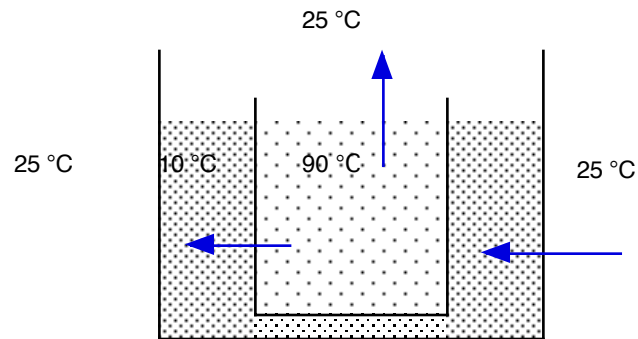
drawing a curve with the correct attitude (1 pt)

for both plots:

transposing the curves (2 pts)

Draw arrows to indicate the direction(s) that heat energy flowed for the temperature difference experiment.

3 pts for each of three correct arrow placements



True or false: The greater the volume of a body, the faster heat energy flows into or out of it.

False (3 pts)

Secret Code: \_\_\_\_\_

Teacher: \_\_\_\_\_

Class: \_\_\_\_\_

Please answer the following questions as well as you can. Use the back of this paper if you need more room to write. If you did more than one design, just answer for the *first* one you created.

- 1) List each material you used in your project design, and briefly explain why you chose to use that material.

10 pts - material listed, with explanation

5 pts - material listed, no explanation

1 pt - anything else

- 2) How much work and thinking did your partner contribute to your project? (circle one answer below)

(5) we did about the same (50/50)

(0) I did not work with a partner

(4) my partner did a little more than me (40/60)

(6) I did a little more than my partner (60/40)

(2) my partner did a lot more than me (25/75)

(7) I did a lot more than my partner (75/25)

(1) my partner did nearly all the work (10/90)

(9) I did nearly all the work (90/10)

- 3) Circle two things from the list below that were most helpful to you in designing your project. Put a star next to the one that was the most helpful.

(1) talking with my family

(5) my lab partner

(2) talking with Mr. Canty

(6) doing ELabBook experiments

(3) doing ELabBook simulations

(7) watching what the other students did

(4) talking with my friends

(8) my own common sense

(0) other:

\_\_\_\_\_

- 4) Write down the features of your project design that you thought were most important to have, and briefly explain why you thought they were important.

10 pts- features written and explanation given

5 pts - features written, no explanation given

- 5) Write down the second law of thermodynamics.

correct: something like "heat flows from the warmer to the cooler body"

resp2: something that mentions heat, but not flow from warmer to cooler

resp3: something that mentiond flow from warmer to cooler, but not heat

resp4: the first law, energy conservation

resp5: any nonsensical regurgitation

## Post-Project Interview A

Conditions: seat the student and interviewer so that they face each other across a comfortable distance. Position a tape recorder next to both people.

Purpose: read the following paragraph to the student

As you know, we have recently finished a project in your science class on the subject of thermodynamics. I am an educational researcher at the University of Michigan, and I am interested in seeing how the students in your class go about learning about thermodynamics. It is important to me that I again find out a little about what you understand about thermodynamics and also about working with computers now that you have completed the project, because I want to see how much you have learned in the past several weeks. This interview is going to help me mark your finishing point. Because of this, I would like for you to give the best answer you can for each question, even if you aren't sure that what you are saying is "right".

Instructions: review the following with the student before proceeding:

- there is no "grade" for the student's answers
- answers, comments, etc. kept in strict confidence
- the interview is being tape recorded; this is a necessary condition so that the researcher may listen to the tape in order to accurately remember what the student has said; the student will be identified on the tape by a code and not by name; a transcript of the conversation or copy of cassette tape can be made available to student, to parents or guardian, or to teacher, upon request
- the student can feel free to refuse to answer if they are feeling uncomfortable
- the interview can end at the student's discretion, but I would prefer to follow three lines of questioning and take no more than 20 minutes
- from time to time I may ask the student to explain what he/she is describing because I want to make sure I understand what they are saying

Begin: ask the student if they are ready to start the interview; when ready, start the tape recorder and verbally identify the student code

Q I have some phrases written on construction paper. I would like for you to arrange these phrases so that they make a statement that you believe to be true. You can use a phrase more than once for the sentence; just ask and I will give you a copy.

*flows around*    *Cold*                    *flows into*    *Heat energy*    *and*  
*higher*                    *Objects at*                    *lower*                    *stays in*                    *Temperature*  
*Heat*                    *flows out of*                    *same*                    *Cold energy*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q Do containers or wraps that help keep hot objects hot also keep cold objects cold?

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer.



Q Let's talk about computers. Think about the ELabBook computer program that you used in class. I'm going to show you a scale, and I'd like for you to rank this program on that scale.

*by far the best I've used*

*I picked this as the best, but I did think about other ones*

*the best, but it was hard to choose over another one*

*it was okay, but I've never used anything I really like*

*this is the only one I've ever used*

Follow ups: Did you like it from the first time you tried it, or did it take a while to learn to like it? What did you like about it? What did you not like about it? Did you think it was easy to use? What did you think about the notes that you were asked to fill in? Do you think this program was of value to you in learning science? Why or why not? Would you want to teach someone else how to use this program? Why or why not? Could you teach them?

---

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School of Education  
The University of Michigan

## Post-Project Interview B

**Conditions:** seat the student and interviewer so that they face each other across a comfortable distance. Position the tape recorder next to both people.

**Purpose:** read the following paragraph to the student

As you know, we have recently finished a project in your science class on the subject of thermodynamics. I am an educational researcher at the University of Michigan, and I am interested in seeing how the students in your class go about learning about thermodynamics. It is important to me that I again find out a little about what you understand about thermodynamics and also about working with computers now that you have completed the project, because I want to see how much you have learned in the past several weeks. This interview is going to help me mark your finishing point. Because of this, I would like for you to give the best answer you can for each question, even if you aren't sure that what you are saying is "right".

**Instructions:** review the following with the student before proceeding:

- there is no "grade" for the student's answers
- answers, comments, etc. kept in strict confidence
- the interview is being tape recorded; this is a necessary condition so that the researcher may listen to the tape in order to accurately remember what the student has said; the student will be identified on the tape by a code and not by name; a transcript of the conversation or copy of cassette tape can be made available to student, to parents or guardian, or to teacher, upon request
- the student can feel free to refuse to answer if they are feeling uncomfortable
- the interview can end at the student's discretion, but I would prefer to follow four lines of questioning and take no more than 20 minutes
- from time to time I may ask the student to explain what he/she is describing because I want to make sure I understand what they are saying

**Begin:** ask the student if they are ready to start the interview; when ready, start the tape recorder and verbally identify the student code

Q I'm going to name a material, and I'd like for you to tell me if you would use it for keeping something hot, keeping something cold, both, or neither.

*aluminum foil    wool                    styrofoam*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q I have some phrases written on construction paper. I would like for you to arrange these phrases so that they make a complete sentence that you believe to be true. You can use a phrase more than once for the sentence; just ask and I will give you a copy.

*flows around    Cold                    flows into    Heat energy    and  
higher            Objects at            lower            stays in        Temperature  
Heat                flows out of    same            Cold energy*

Follow ups: What is the main reason for your answer? Describe a situation to illustrate your answer?

Q Let's talk about computers. Think about the ELabBook computer program that you used in class. I'm going to show you a scale, and I'd like for you to rank this program on that scale.

*by far the best I've used*

*I picked this as the best, but I did think about other ones*

*the best, but it was hard to choose over another one*

*it was okay, but I've never used anything I really like*

*this is the only one I've ever used*

Follow ups: Did you like it from the first time you tried it, or did it take a while to learn to like it? What did you like about it? What did you not like about it? Did you think it was easy to use? What did you think about the notes that you were asked to fill in? Do you think this program was of value to you in learning science? Why or why not? Would you want to teach someone else how to use this program? Why or why not? Could you teach them?

---

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## **APPENDIX B**

This Appendix contains transcripts of the PreInterviews. The page after this one has the rubric that was used to assess the students' responses.

## Interview “Word Scramble”

Heat energy	stays in	Objects at	cold
Temperature	flows into	and	Heat
Cold energy	flows around		higher
	flows out of		lower
			same

*The phrases which demonstrate deep understanding:*

Heat energy flows out of objects at higher temperature.  
Heat energy flows into objects at lower temperature.

*The phrases which demonstrate moderate understanding:*

Heat flows out of objects at higher temperature.  
Heat flows into objects at lower temperature.  
Heat energy stays in objects at same temperature.  
Heat stays in objects at same temperature.

*Other phrases demonstrate low understanding.*

*The inability to generate a phrase is denoted as a “null” response.*

## Interview Insulating Materials

*The response which demonstrates deep understanding:*

A: Yes, Materials are equally adept because they “impede” or insulate against molecular transfer of heat energy in an equidirectional manner.

B: While all three would work to some degree, wool and styrofoam are more effective insulating materials than aluminum foil. Any situation that is a viable representation is fine.

*The response which demonstrates moderate understanding:*

A: Yes. Materials are equally adept because they provide a physical barrier to macroscopic transfer of heat energy in an equidirectional manner. May be accompanied by a desire to perform a test such as an ELabBook simulation to look for a solution.

B: All three would work to some degree. Any situation that is a viable representation is fine.

*Other phrases which demonstrate low understanding.*

A: Yes, sometimes or no. May make a blanket or specific appeal to experience.

B: Any choice that identifies one or materials as good for “just” keeping something hot or cold, rather than

both.

*An answer of “I don’t know why” or similar inability to formulate a reply is denoted as a “null” response.*

### **Computer Software (pre)**

Categorize the software into one of three choices: telecommunications, multimedia, or software tool. Email or chat would be examples of telecommunications, games would be an example of multimedia, and educational or office software would be an example of a tool.

### **Computer Software (post)**

Compare ELabBook with the software they described before. Compare each of their answers, focusing especially on like/not like/ease of use/teach others.

Q-1: *This is Tuesday and this is the first interview during second period. I've got a couple of things here that I want you to look at. First of all, I have some phrases that are written on this construction paper. I'm just going to take this paper (I'm going to put this over here) and I'm going to take this off. What I would like for you to do, and I don't know if you've done anything like this before so take your time, is arrange these somehow in a sentence that makes sense to you. You can use all the phrases or you might just use a couple of them. If you feel like you want to use another phrase more than once, just ask me and I can give you a second copy of it. But just go ahead and take your time. You know, don't worry about anything else and just arrange them in a way that you think is a true statement about thermodynamics, about science, something that strikes you as true . . . (short pause) . . . You can go ahead and think out loud, if you want. That's okay. I'm interested in what you're thinking.*

A-1: . . . (long pause). . . now, let's see.

Q-2: *Okay. Are those the ones? Is that the one you picked? Could you just go ahead and read that?*

A-2: Cold energy flows around and flows out of objects at lower temperature.

Q-3: *Okay. Why did you think that . . . why did that strike you as something that is true?*

A-3: Well, cold comes out of . . . is low temperature as it flows around and flows out of different objects.

Q-4: *Okay. Did you have anything in mind when you thought of "flows around or flows out of"?*

A-4: Well, I felt it flows out of an air conditioner.

Q-5: *Okay. Why did you think of an air conditioner?*

A-5: It's the only thing I could think of really besides . . . I don't know. . . but . . . like, besides wind that comes out of . . . that flows out of the air conditioner.

Q-6: *What made you think . . . I mean, do you have an air conditioner at your house?*

A-6: Yeah.

Q-7: *What about "flows around"? What does that . . . in your head . . . what do you think of when you think of something within this sentence here?*

A-7: Oh, just cold temperature flowing around and like circulating into the air. . . just coming out of something circulating around.

Q-8: *Okay. This word over here -- "cold energy"-- what did that bring to your mind?*

A-8: "Energy" has something pushing it out and "cold air" is like, I guess, has energy to push out the cold air.

Q-9: *Okay, what about this word here "lower temperature"? What is that?*

A-9: It's cold. It's low temperature.

Q-10: *Okay. Okay. You thought about an air conditioner. That sort of made you think about this, right? Or is one thing . . .*

A-10: Yeah.

Q-11: *Is there anything else that you might have thought about when you saw all this?*

A-11: It's something like . . . like if you had a window that wasn't sealed right or that the cold air could come through into your house and break through in your house.

Q-12: *Okay. Okay. What I'm going to do is, I'm going to go ahead and pull these out and I'm going to ask you another question. . .*

**Q-13:** ... *and my questions is, do containers or wraps that help keep hot objects hot also keep cold objects cold?*

**A-13:** I think so because like you just wrap around something and it'll just keep the temperature what that is in there. It won't let that temperature release out of it. It'll just keep it in there so whatever it is, it'll probably keep that temperature. . . probably keep it.

**Q-14:** *Okay. What do you mean when you say, "it'll keep the temperature inside of it?"*

**A-14:** I usually use something . . . some hot water into a bowl and put some kind of wrapping around it, it'll probably keep it where -- if you get it like sort of tight like -- it won't release . . . like the vapors won't . . . the hot vapors won't release out of it so it won't get colder. It'll get colder little by little and stay colder longer . . . or hotter longer. If it was cold water, it'd probably do the same thing.

**Q-15:** *Okay. In this case, what does "temperature" mean to you? The way you just used it?*

**A-15:** Either "hot", "warm" or "cold" or I guess, temperature is "degrees", I think.

**Q-16:** *Can you think of a situation that is sort of . . . like the last time you thought of an air conditioner . . . did you think of something else when I mentioned this? If you didn't, can you?*

**A-16:** (chuckle) . . . I was thinking about when my dad made chile last night, he put the whole . . . all the container in a thing and put a wrapping around it so it would keep it warm so . . . 'cause I wasn't home yet . . . and he kept it warm so when I got home it would be warm so I didn't have to re-warm it.

**Q-17:** *What wrapping did he put around it?*

**A-17:** He just kept it in a pot and put some . . . uhh, it looked like saran wrap or whatever that stuff is . . . that's gold. I don't know what it's called. It's not the clear stuff but the other stuff that he wrapped around it and just sort of stuck it in the oven.

**Q-18:** *Okay. Can you think of common things that people use to wrap objects to keep them hot or cold?*

**A-18:** (indistinguishable) you can make lids yourself or you can buy like saran wrap or "what do you call that" and stick it on there or like attach it to a pot iron or something.

**Q-19:** *Umm Hmmm, if you had to pick the best object you could think of to keep something hot or cold, what would you pick and why?*

**A-19:** I'd probably like use one of those, umm, thermoses that are supposed to do it . . . that keep coffee hot and stuff, and would probably keep it pretty warm and stuff.

**Q-20:** *Okay. What is it about a thermos that does that? What do you think why a thermos . . .*

**A-20:** (indistinguishable sound) 'Cause the people that make them . . . make them put, I forgot what it's called, but when you see the bottom, you see the thing in a diagram it shows different layers of why it keeps it warm and why to buy it . . . like there's different layers are supposed to be really made for it. Stuff like a container when you put food into it just like to keep it fresh.

**Q-21:** *Okay, now earlier you talked about air tightness. Do you think that's important for a thermos too?*

**A-21:** Yes, so that the vapors don't get out and other air come in to mix an element that could either . . . try to make it like room temperature.

**Q-22:** *Okay. Okay, that's good. Do you have anything else you want to add on that?*

**A-22:** No.

**Q-23:** *Okay. There's one more question I'm going to ask and that's about computers. I'd like for you for a minute to think about the different computer software you've used. Have you used a lot, or not much, or . . . ?*

**A-23:** I use it sometimes.



Q-24: *Okay. Now, think about anything at all. It doesn't have to be educational. It could be, you know, games. It could be stuff like multi-media. It could be stuff you use here at school or stuff you use at home and tell me what your favorite program was, if you can pick one.*

A-24: I like the CD ROM, just like the graphics are real cool. It looks just like real people and stuff.

Q-25: It looks just like, I'm sorry, like what?

A-25: Just like real people. Looks like you're playing a movie.

Q-26: *Okay. What do you do with that CD ROM?*

A-26: Just play different games . . . and watch . . . like they have this video on the zoo that's just like real footage. And you can make them like different stuff, like watch them how they eat and what their eating habits are, and stuff.

Q-27: *Now, I'm going to show you a scale here, on this piece of paper, and I want you to tell me . . . rank the program you just described on this scale. Pick one of these four that seems to fit it the best.*

A-28: The top one.

Q-29: *This one? Could you read what that says?*

A-29: By far the best I've used.

Q-30: Okay. Now, why would you say that this was by far the best you've used?

A-30: You can . . . the computer head has . . . the CD ROM has everything . . . so you can, like if you went to a computer store to buy software for it you could probably buy anything they had. Most high tech stuff would work probably and you could get additional hook-ups for it and get Prodigy, once you have some stuff hooked to it.

Q-31: *Okay. Did you like it the very first time you tried it or did you take a while to learn it?*

A-31: It was like . . . (short pause) . . . first, it took me a few minutes to like learn it because the computer I got is like a real old one. And it's like, it don't have windows or anything and you got to write the code in and it's slow and it don't got much games or anything on it really to use.

Q-32: *Okay. Was there anything about this that you didn't like?*

A-32: Not really.

Q-33: *Okay. Did you think it was easy to use for you or for anyone else?*

A-33: It really depended on what CD or what program you're running.

Q-34: *Umm Hmmm. What about for you? How did you find it?*

A-34: I don't know. You could put it on easy or harder levels or whatever. You could put it on whatever you wanted. It was pretty easy if you set it the way you wanted it to.

Q-35: *Okay. Now, do you think this program would be any value to you in learning science?*

A-35: (indistinguishable) There's a bunch of fun things you can get disks for it and you can get science disks for it . . . like on just what we're doing now . . . like demonstrate and what you're doing. Somebody can get some kind of thing and put it in a computer and it'll tell you . . . like you can set a container and put something in it and it'll tell you if it did keep it cold or if it did keep it hot.

Q-36: *Okay. Would you want to teach someone else how to use this stuff that you're describing, this CD ROM with games?*

A-36: Yes.

Q-37: *Why?*

A-37: Because they'd probably like it and enjoy it. It's almost like there isn't really no stop to it, to what you can do to it and you can keep on going and do different stuff.

Q-38: *Okay. Is there anything else you want to add to any of the stuff I've asked you?*

A-38: No.

Q-39: *Okay. I think we're done. Does that sound okay?*

A-39: Yeah.

Q-40: *Okay. I'm going to stop the tape now.*

Q-1: *I'm going to let it run for a second. The first thing I'm going to do is . . . place these here. What I'd like for you to do is . . . These are all phrases and I'd like for you to arrange these in a sentence that seems to be true to you or something that makes sense to you or something that you've heard . . .*

A-1: . . . like a fact or just an opinion or something, or just any normal sentence?

Q-2: *It can just be a normal sentence that you think is true, so I guess that's either opinion or fact. You don't have to use them all. If you want to use one more than once, I'll be happy to give you another copy . . . (short pause) . . . and take your time.*

A-2: Okay . . . (long pause) . . .

Q-3: *You can think out loud, if you want. That would be fine.*

A-3: I can't think. 'Cause it's like temperatures. That means temperature. I'm not sure about temperature.

Q-4: *You can make that "temperatures" (plural).*

A-4: Umm . . . (long pause) . . . I don't know if I can make a sentence out of this. None of this. . . it's like just scattered around and none of it makes sense to me . . . not at all.

Q-5: *If you can say something . . . like is there a thought in your head that . . .*

A-5: On this?

Q-6: *Yeah.*

A-6: No. It's talking about "temperature" and "heat" and stuff, like "heat energy" and just certain words of things about heat and stuff. I can't make sense of it. Umm. Heat, energy, temperature. Umm.

Q-7: *Can you . . . do some of these things seem to be saying the same thing?*

A-7: Saying the same thing?

Q-8: *Umm Hmm.*

A-8: Things like "flow to" "flow out of" and . . . "flows around". "Heat energy", "heat " and "temperature" seem to say the same thing.

Q-9: *Okay. Why do you say that?*

A-9: 'Cause they're basically . . . They basically are related . . . sorta . . . like "heat" and "heat energy" are basically the same thing.

Q-10: *Umm Hmm.*

A-10: In order to get heat, you need something to energize it, which is sorta like "energy"; and "temperature", it ranges from hot to cold; and "cold energy", I never heard of. I never heard the phrase "cold energy" together before.

Q-11: *Okay.*

A-11: And "low" and "high" are just opposite things and temperatures can go like "high" and "low". Flows heat? Energy can flow around something into, I'm not sure what you can say "objects" but I can say "at" like "energy flows around objects at", I can't say "higher". Higher what? Temperatures . . . lower temperatures . . . that's another thing. It's just a bunch of things.

Q-12: *Is there something that you have in your head . . . a machine or some phenomena . . . that you can associate with "heat" and "cold" or "heat energy" and "cold " or "temperature"?*

A-12: That associates with this?

Q-13: *Yeah. Is there something that you think about when you think about "heat energy" or*

"temperature"?

A-13: No, not really. I just think of "heat". What pops in my head is a heater.

Q-14: *Okay. What kind of heater?*

A-14: A . . . some . . . a circuit heater that has . . . that heats off of dry cells that flows on through the pink wires around to different objects and stuff like that. That's what pops in my head.

Q-15: Okay. Do you have one of those?

A-15: I had one . . . (chuckle). . . I made one for a science project book report.

Q-16: Oh, okay. . .

A-16: Right. That was last year. That's why it pops in my head because it's familiar from last year when I had did a project with these words.

Q-17: Umm Hmmm, okay. Was this a science year project from last year?

A-17: Uhh huh. (indistinguishable) Mr. Jules. We had one for "circuits" and he like helped in teaching how this particular dry cell produce and and how much (indistinguishable) this particular dry cell, and how does the electricity through the dry cell, or whatever you want to call it, flows through the wires (indistinguishable). You know, like that.

Q-18: Okay. Okay. That sounds pretty good. I'm going to move these out of the way now.

A-18: Umm Hmmm.

**Q-19: *I'm going to ask you a second question and that 's, do you think that containers or wraps that keep hot objects hot also keep cold objects cold?***

A-19: No.

Q-20: *Can you explain why?*

A-20: Uhh, its like you can have an, like for instance, a mug that's locked tight that's supposed to keep your cup hot. It can keep it warmer for probably a little bit longer while its hot and normally just sitting out but after a little while, it'll just get cooled down as usual. And cold objects, any plastic bag or container that you keep it in, unless that particular container keeps it cold, it'll probably just warm up after a little while. It won't stay cold unless it's like frigid or something like keeps it cold, like ice or something. Unless you add something real cold, the container will just eventually get warm at some point and something real hot in a container or bag or whatever eventually cools down. That's just how it is.

Q-21: *Did you have something in your head as you were saying all that? What I mean is were you picturing something in particular? Or could you point to something like a real object . . . or a real thing?*

A-21: Yeah, I can say like, when you go to the grocery store to buy meat that's frozen. It's locked tight, you know, air tight where nothing can get to it and if you was to leave that meat out eventually it would get warm 'cause usually it would like cool down or get unthawed or unfrozen or like that. Like we do when we cook it, you know, sometimes we let it thaw for a little while. So, now that's what happens. It eventually cools down. And with hot things 'cause I got my mom a mug that supposed to keep it hot all the time and eventually she drinks some of it in her car, she leave it locked tight, you know, where no air can get in or out. She goes to work and after she come back from work, the cup has cooled down already.

Q-22: *Okay. Was there anything in common between those two things, those two examples, you just gave?*

A-22: Anything in common about it?

Q-23: *Umm Hmmm.*

A-23: Yes, but I can't think about the words.

Q-24: *Well, I thought when I heard you talk about keeping things cool and keeping things hot*

*you talked about "air tight" both times. Can you explain what is important about keeping things air tight?*

A-24: Uhh, 'cause different . . . 'cause . . . like if you have something cold and it was locked air tight, and it's just like warm heat or certain different warmer gases or stuff, or just warmer gases I should say, or just normal air, warm air, can get to it and cool it quicker if it was a cold object. But when it's locked tight without any air getting in or out, it'd stay colder longer but it'll eventually cool down 'cause the wrapping or container it's in could probably get it warm and then go ahead and throw in the cold air would, you know, cool it down, or thaw it whatever. And something hot, the same way. Cold winds could get to it. It's like keeping yourself warm from the outside cold, you wrap yourself up tight where no air can get in and when it does, it cools your body. Like when you get cold eventually . . . like that.

**Q-25:** *Okay. Okay, that's good. Let's . . . I want to go on to another thing and it's about computers. We've been talking about science. Have you used a lot of computer software?*

A-25: Software?

**Q-26:** *Or do you think you use a lot, or just a few, or . . . ?*

A-26: I have. Yeah, I've been using computers a lot. I use this computer in here every day. And I have computer classes. I've had three computer classes in the past three years. In fact, I'm in one now and I'm familiar with them, and I use them a lot and I like using them, so I continue to take a lot of computer classes.

**Q-27:** *Oh, really. What do you like about them?*

A-27: I like just what it can do -- the different kind of things it can do. The way you can make things, graph things, or print it out in all different kinds of colors. I just like the things it can do 'cause it makes it easier for me, you know, instead of writing 'em out and everything.

**Q-28:** *Hmmm. That's interesting.*

A-28: 'Cause I'm not a very good drawer when it comes to graphics and stuff.

**Q-29:** *Okay. Well, of all the computer software you've used, which one do you like the best?*

A-29: What type of computer or just computer software?

**Q-30:** *No, just the software.*

A-30: Umm. I'm not sure. I'm not familiar what software I've used. Really, 'cuz in the classes I'm in . . . it was, uhh, . . . the (what type of software). Gosh, I just finished one. I can't remember what's the name. It's something the whole school uses. I can't remember what type of software.

**Q-31:** *Do you know what you do with it?*

A-31: . . . I work with . . . I'm familiar with it but I don't like know all the facts about it. I'm familiar with what things you can do to it to make it work but, like, what this is or where this come from, or what's the name of it, I'm not familiar with it. But, if I was to see it, I'd know what it was.

**Q-32:** *What I meant was, what do you do with it? Is it a drawing program, a writing program, a game, or a science program?*

A-32: I have games and research. Like on an assignment. Research is like to read about things or tell you about certain things about the computer and drawings, I do and right now, I am in photographing to make . . . to do different things to a picture and make it look real, still like a real photograph. That's what I'm doing right now.

**Q-33:** *Okay. So, go back and think about the one that's the best out of all of them -- the one that you like the best.*

A-33: I'm doing (indistinguishable).

Q-34: *Ummhmm.*

A-34: Umm. Let's see. I . . . I like them all, except for the research. That one I can miss. I can read research and get a lot out of it and won't mind reading to get the information I need but when I have to do work with it, I have to scan through it and ask Mr. Donnes (?) if I can have it done in a certain period of time. So, I like all of it.

Q-35: *Okay.*

A-35: Except when I . . . like skim through it real fast to get the information down for something in the end, after we finish with it, they expect us . . . they expect me to know everything I done read about it when I really scan just to get the answers outside of my head.

Q-36: *Okay. Now, I'm going to ask you, is there anything in particular you don't like about software?*

A-36: Nothing I know of I don't like.

Q-37: *Or maybe one particular program? When you see something, you say "I really don't like that".*

A-37: No, I like them all.

Q-38: *Do you think that the stuff that you've used could be used for learning science?*

A-38: Umm, very much.

Q-39: *Okay. How so?*

A-39: Science . . . get science . . . certain science programs for the thing. I don't just mean science programs but like a game that helps you with your science . . . like they have the math machos. That particular program helps you with math. And like some programs, science programs, you can put into your computer that helps you with science, you know.

Q-40 *Okay. Is there . . . <sup>munchers</sup> uhh, can you think of some software that you'd like to teach other people to use?*

A-40: Umm, other people to use . . . depends on what they are interested in. My friends are not interested so it would be hard for me to teach them something they are not interested in. Find out what they are interested in, like . . . with someone interested in drawing, I'd like to teach them how to use some of the tools. . . uhh interested in . . . depends on what they are interested in. I could not teach them any math.

Q-41: *I'm more wondering, could you teach somebody about software, assuming they were interested?*

A-41: Yeah, if I knew about it . . . if I was familiar with it myself, I could teach them, but if I wasn't, it would be hard for me to teach them.

Q-42: *Okay. All right. Is there anything you want to add about any of the stuff we've talked about?*

A-42: No.

Q-43: *Okay. I think we're done. I'm going to shut the tape recorder off now.*

(CHANGE TO SIDE B OF TAPE 1)

- Q-1: *The first thing I'd like for you to do is . . . I have some phrases right here on paper and what I'd like for you to do is just arrange these in some kind of a sentence that seems to make sense to you, or a sentence that strikes you as true. So, just go ahead and take your time to do it.*
- A-1: (long pause) . . . This is hard.
- Q-2: (chuckle) . . . *if you want to think out loud while you're doing this, that would be okay.*
- A-2: Do you want to know what it says?
- Q-3: *Yes.*
- A-3: Heat energy flows out of objects at higher temperature.
- Q-4: *Okay. Now, can you tell me why you think that's something that's true?*
- A-4: Well, because heat . . . it, you know, it gives off a lot of energy so if it flows out of an object, it's going to naturally have a lot more energy and more energy is heat and higher temperature.
- Q-5: *Okay. What I . . . could you explain a little more about what you think "heat energy" is here?*
- A-5: Well, heat energy is like . . . when things have . . . they run against each other they have friction together and, uhh, and it builds up a lot of friction between the two objects. The friction generates all the energy that's going between the two as they run together it's got a lot of heat and, you know, it gives off the warm feeling and stuff like that.
- Q-6: *Do you have anything in your head that you're picturing as you're telling me all this?*
- A-6: Like . . . like hands. If you run hands together, all that energy that builds up when you're rubbing them together, it generates heat. So, when you stop, you have heat in your hands because of all the energy that's caused with the friction as you rub them together.
- Q-7: *Okay . . . what about this term over here -- "temperature"? What do you think of that?*
- A-7: Well, "temperature" is like . . . it's a feeling of how hot or how cold something is. Like, if you say the temperature of the water is hot, you know that the water feels hot. You know, temperature is associated with feeling and how it feels.
- Q-8: *Okay. I was going to ask you . . . do you think that this word here "flows out of" . . . what does that sort of do . . . what does it generate in your head?*
- A-8: Like when you rub your hands together and all that energy . . . it means like when it's released. Like if you keep them like real close together, energy still stays in your hand but if you stop, the energy flows out from, you know, the friction it causes. It means like it releases the energy and the heat and the temperature and everything like that.
- Q-9: Okay. Is there anything you want to add to anything you've said so far?
- A-9: (inaudible)
- Q-10: Okay. Well, what I'm going to do is I'm going to round these up . . .
- Q-11: *. . . and the next thing I want to ask you . . . which is my second question . . . and that question is, do you think that containers that keep things hot also help keep things cold? In other words, the same container or wrap or whatever.*
- A-11: Yeah because temperature is basically the same whether it's hot or cold. If you can contain the one, you can contain the other.
- Q-12: *Okay. Can you . . . do you have something . . . an example in your mind?*

A-12: Like thermoses. If you . . . uhh . . . if you have a thermos, to keep like maybe, if you put a Canada Dry in a thermos, it's going to keep it cold but if you put soup in a thermos, it's also going to keep it hot because it has that insulation that keeps whatever the temperature is inside, it keeps it the same because it doesn't let the energy and the temperature and the stuff like that flow out. It keeps it contained so it doesn't release the heat or the cold that's inside.

Q-13: *Okay. What is it exactly about the insulation or about the thermos that does that?*

A-13: I don't know.

Q-14: *Well take . . . you know, just imagine.*

A-14: Maybe it's the material that it's made of. Maybe certain material in the thermos contains it so that when the energy goes to release itself -- 'cause naturally it's going to try to stay the energy tries to go and release the energy that it has and something in it is going to try to propel it, so that it keeps going back. So if the energy keeps bouncing off the walls inside of the thermos, then it's still going to keep that thing warm or cold.

Q-15: *Hmmm. When you talk about energy bouncing off the walls, is it . . . what are you thinking of when you think of energy bouncing off the walls?*

A-15: Like . . . like a ball. If a ball tries to go out, it can't because something is holding it in. The insulation is like a barrier around it. Well, I think that the ins[sic]. . . you know, the energy is like the same thing. When it tries to get out, it can't because something is containing it so it just keeps bouncing against the walls trying to get out but it can't because something's containing it.

Q-16: *Okay. Okay. Anything more you want to add to any of that?*

A-16: (inaudible)

Q-17: *Okay.*

Q-18: ***The last thing I want to do is I want to ask you about computers. Now, think about it . . . do you use computers at all, or a lot, or a little . . . ?***

A-18: It depends because I don't have a computer at home, so when I come here I get to use it because I have computers this quarter, so I'm using it at school; and like maybe if I have to do a report or something, I use it at my parents' jobs but that's it.

Q-19: *Okay. Think about all the software you've used, okay -- different computers and different places -- but think of the software, can you pick out one piece of software that you think is the best, the one you like the most, the one that's your favorite?*

A-19: Well, my favorite would probably have to be like *Number Munchers* because it's, you know, like a game because like with that you've learned about your numbers and everything like that. You also get hand-eye coordination because you have to eat the numbers while they are on the screen and you also have to be aware because you have things chasing you but you also have to keep in mind what you're eating because if you don't, then you'll die. Either way, if . . . you know, you have to be aware and be alert as you play the game. You also have to get the hand-eye coordination because you have to keep in mind the people who are chasing you and you got to concentrate on the numbers and, you know, like multiples and stuff like that. You also gotta know where to move and when to click, you know, to eat 'em and also keep right on top. So, it's like you have to have all your senses alert to play the game to succeed.

Q-20: *Okay. Now, I'm going to show you a chart scale here, and this software that you've mentioned, could you . . . which one of these would you say . . . would you rank that at?*

A-20: . . . (short pause) . . . Probably this one.

Q-21: *Could you read that one?*

A-21: I picked this as the best but I did think about other ones.



Q-22: *Okay.*

A-22: Because, there's . . . I mean, you can't . . . if you use computers a lot, you can't just narrow down one software, one program, because they all have different characteristics that you like but I picked *Number Munchers* because it has the most characteristics, you know, that appeal to me because, you know, the other ones, like maybe one program might have the brain stimulation that you need and makes you think; the other one might have the hand-eye coordination that you have to stay alert; another one could . . . I mean, it . . . there's a whole bunch of different characteristics and different programs that might appeal to somebody but for me personally, *Number Munchers* has the most contained in one.

Q-23: *Okay.*

A-23: There's a lot of other ones but . . .

Q-24: *Okay. Did you like it the first time you tried it or did it take a while?*

A-24: Well, I liked . . . I liked, you know, trying to get it. It was hard the first time because you know, I was like . . . it was like a couple of years ago, and I didn't even know my numbers that well. So, it was kinda . . . it was hard but it made you want to try it again so like you could, like, just score. It's a very competitive game but it also makes you learn and stuff like that.

Q-25: *Ummhmm. Okay. Do you think . . . do you find it easy to use now?*

A-25: It's easy to use now and yet . . . it's still stimulating. It still makes you think. It's easy to use because . . . I mean, you only need like five keys plus the arrow keys and the space bar . . . and the return key, of course and it's not really that difficult because you don't have to go through a whole bunch of codes and go through a whole bunch of reading and stuff like that. All you have to do is learn your numbers and keep alert and know the keys and everything like that. It's not that you have to do a lot of typing and things like that. It's not that type of program.

Q-26: *Okay. Is there anything about this program that you don't like?*

A-26: Not really. I mean, they have different levels that you can go on and if you . . . and then they have a Hall of Fame so that everybody score and everything like that. And then, there's not really anything that's not . . . but when you get up to a certain age it's too easy. It's for a certain level. I mean, it goes from fifth grade math to eighth grade math. That's the, you know, area but if you want to refresh your memory on numbers, like if you're higher than the eighth grade, if you, you know, keep trying, you know, and keep drilling. If you want, like a drill or like an exercise, you can play this but . . . and if you want to try something harder, like if you are below the fifth grade and you want to try something, you know, harder than that, than what you're getting, this would be the perfect game.

Q-27: *Okay. Okay. Do you think this program would be of value to you in learning science?*

A-27: Not really. It's more toward a math-based program.

Q-28: *Maybe if we pictured a science-based same-kind-of-program.*

A-28: Yeah, because it has different categories . . . like you could do math. But if you go . . . there are a whole bunch of different munchers, like there's math munchers, weird munchers, and then there's super munchers where you can pick animals, different and like birds, animals, reptiles, in all those different places. Then you have the geographical one where you can pick the different places, like which ones are in the Continent of Africa and go all around and pick from those. It just depends on which one you get. There's different ones and there's one for English, like you can pick the words, which ones are nouns and which ones are verbs and things like that.

Q-29: *Okay. Do you think you'd want to teach someone else this program?*

A-29: Sure, if they needed help with hand to eye coordination and thinking and stuff like that.

Q-30: *Okay. Do you think "you" could teach?*

A-43: Me, personally?

Q-31: *Yeah.*

A-31: Well, it depends 'cause I'm not really that well in English so I couldn't teach the word munchers, but the other ones is easy to do. I probably could teach that.

Q-32: *Okay. Do you have anything you want to add about computers that you didn't get to say?*

A-32: It's good that people are introduced to computers early and that, you know, they get challenged because this world now is based mainly on computers. So, if you don't know how to use a computer, then likely you won't be able to get a good job because you don't use typewriters and hand-written things much anymore. You usually use a computer. And, if you have to get reports out or give reports to people, you usually fax them and send out messages on the computer. I mean, you can talk to them on computers now. It's a whole bunch of things that computers are worth. Now, when you get a job now-a-days, you have to know how to use a computer.

Q-33: *Okay. I guess . . . I think that's it. I think we're all done. I'll shut this off here.*

- Q-1 *I just started the tape recorder. You know, this is my fourth interview of the day already. What I'm going to do is, I'm going to drop some phrases here that I wrote out, and what I'd like for you to do is just to pull these out and try and make a sentence out of them that you think is true, something that makes sense to you, something that you agree with . . . and go ahead and take your time and do this . . . (long pause) . . . say you may not use all these phrases and if you need to use a copy of one, I can give you a copy of one . . . (long pause) . . . if you want to think out loud, you can.*
- A-1: Okay . . . (long pause) . . . Hmm . . . something doesn't make sense . . .
- Q-2: *Is there anything in particular you're trying to get at?*
- A-2: Well, like one thing I know is . . . I know that heat, you know, starts from the top, and, you know, like if you turn on the heat, the first place that's warm is the ceiling and it slowly . . . the heat slowly works its way down . . . so I can't think of how to say that.
- Q-3: *Well, that's okay. We can work with that . . . with what you just said. Why do you think . . . why do you think heat does that?*
- A-3: Because it's lighter . . . than uhh . . . you know, the warmer air is lighter, you know, so it's lighter than cold air.
- Q-4: *Okay.*
- A-4: So slowly replacing the cold air.
- Q-5: *Okay.*
- A-5: . . . I suppose.
- Q-6: *What . . . so you're talking about . . . are you thinking about anything in particular when you're describing this to me? Is there a picture in your head of something?*
- A-6: Well, first of all, on that one, I was thinking about fire because when there's fire someplace, the smoke starts at the top and it goes down so you're supposed to like lay on the ground and I remember learning that in the beginning of . . . well, not learning it originally but we talked about it in the beginning of the year, I think. I can't remember. There are some things I have trouble remembering, I think.
- Q-7: *What do you think of when you think of this word "heat"?*
- A-7: I think of the energy in like the air. I think of warmth, you know, basically. You know, I think of a lot of energy because the temperature of something is, you know, how much energy is in the air and so heat would probably be more than cold, so . . . I'm uhh, bewildered.
- Q-8: *When you say "heat" is more than "cold", what is more?*
- A-8: There's more energy in heat than in cold. (Indistinguishable).
- Q-9: *Okay.*
- A-9: This stuff's tough.
- Q-10: *That's okay. Actually, I think you've explained some stuff that I'm looking for already.*
- A-10: Okay.
- Q-11: *I was going to ask you . . . what do you see . . . is there anything else . . . a difference between hot and cold or heat and cold besides what you've said?*
- A-11: I know that there is hot . . . well, like . . . well, there's the thing where uhh condensation and things like that, evaporation, come in where you heat something up . . . if you heat a liquid up, it turns from liquid to solid. If you cool a solid . . . if you cool a solid, it turns . . . not a solid . . . if you heat a solid, it can turn from . . . it'll turn from solid to liquid and if you heat a liquid, it'll turn from liquid to gas. If you heat a gas, it'll turn . . . er . . . no, if

you . . . if you cool a gas, it'll turn from gas to liquid. Yeah, condensation, evaporation, and stuff like that.

Q-12: *Okay. All right. I'm going to go ahead and collect these and I'm going to ask you a second question.*

Q-13: *What I'm going to do is I'm going to name a material, okay, and I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both, or not for doing either one. Okay? First material is aluminum foil.*

A-13: That would be to keep it warm.

Q-14: *Okay.*

A-14: No, wait . . . scratch that . . . cold. To keep it cold.

Q-15: *Now, why would you say . . . "*

A-15: No, wait, for both.

Q-16: *For both. Now, why would you say that?*

A-16: I was thinking of like when my mom cooks, yeah, I'm thinking of non exceptions like when my mom cooks a turkey, when she takes it out, she puts uhh aluminum foil on it to keep the heat from escaping but then if you put a can of pop or something like that in someone's lunch, wrapping it up in aluminum foil will keep it cold. I believe that's so.

Q-17: *Okay, so you would use it for both. What about wool?*

A-17: Wool . . . that would be for keeping something warm.

Q-18: *Okay. Now, why do you say that?*

A-18: Because wool is a fabric used in clothes and, you know, that traps . . . it kind of traps the heat that's already in . . . you know, like blankets, you know, kinda like the atmosphere, it keeps all the air in but it keeps you from getting, you know, any outside forces or whatever to not getting . . . you know, just keeping the heat in basically.

Q-19: *Okay. What about Styrofoam?*

A-19: Neither. Styrofoam. No, Styrofoam would be used for keeping something warm.

Q-20: *Okay. Why do you say that?*

A-20: Well, I say it because I worked over the summer in a restaurant and we used Styrofoam things -- they use them in restaurants all the time -- to trap the heat and heat can't escape from it and but I wish people wouldn't use it for anything but, you know, they keep stuff warm.

Q-21: *Why do you say they shouldn't . . . you don't want them to use it?*

A-21: Because it's not biodegradable. It's the worse trash in the world.

Q-22: *Okay. Is there anything that's similar about aluminum foil, wool and Styrofoam as far as what we talked about?*

A-22: Well, they're all for . . . you can use all three for getting heat and trapping the heat that's already there in and gathering it, I guess, in some ways.

Q-23: *Okay.*

Q-24: *Okay. We're going to go ahead and talk about the computer now.*

A-24: Okay.

Q-25: *You said that you've used it a lot. I'd like for you to think about all the different software that you've used and, uhh, can you pick out one program that you think . . . that you would say is your favorite?*

A-25: One program that's my favorite. Uhh . . . this is a toughie. I'd say either *Quicken* or *Sound Edit*.

Q-26: *Okay. Now, why was that a hard decision?*

A-26: Because I like all the . . . most of the . . . almost all the software that I've used equally but it's like, you know, I like all the games that I play on the computer; but I like, even more than I like to play the games on computer, I like to do the stuff like *Quicken*. I love that because, you know, you can do your own like write checks and all that and post stuff. You

know, for someone who's young for when you get old and you have to do taxes and, you know, keep a budget and home income and, you know, inventory and stuff like that. It's useful when you're not a . . . when you're, you know, when you're getting a steady income and things like that when . . . after you've graduated, so . . .

Q-27: *Okay. I was going to say . . . what . . . did you like "Quicken " the very first time you tried it, or did it take a while?*

A-27: I . . . when I first saw it on TV, I talked about it. I was like "Sounds cool". When I first, you know, messed around with it, with a friend of mine, it was like tough to understand at first because it was the first time doing anything with it but then after a couple of times, I got the hang of it and I like it a lot now.

Q-28: *Okay. Do you manage your own . . . (CHANGE TO TAPE 2. Transcriptionist Note: From this point to A-30, I accidentally pushed the record button down and erased the tape when I went back to check on a word. This happened after I had transcribed it, so even though it was transcribed, it is no longer on the tape.)*

A-28: . . . where I'm broke, so . . . It's like I look at a lot of real soft grid stuff, usually offices and stuff like that, and I like . . . (short pause) . . . sound bite. I just like that because it is like preferred stuff.

Q-29: *Okay. Is there anything you don't like about the grid or the sound bite, or you don't understand about it?*

A-29: Not really.

Q-30: *Anything about using the program itself that you find difficult or wish they had done another way?*

A-30: Well, I wish that someday that . . . you know that . . . like you could change the time. . . if you have, I don't know how you could make it longer. . . uhh. . . you know, more time to record so that you could record more than . . . uhh. . . now you can. But, see, they do it with Kid Pix, you know, it's all that's basically used now. You know you use that a lot and with Kid Pix, you can, you know, record like 30 seconds but then with this, you can record a little more but I wish you could record more but I don't have much more in mind.

Q-31: *Okay. Do you think either of these programs would be of value to you in learning about science?*

A-31: Yeah, because . . . in a way, because . . . uhh . . . (short pause) . . . I like the sound of it, you know, there's different types of ways you can. . . different things you can do with the sound and, you know, things like that and I can't think of really what you can, well, can learn about science, but . . . (pause) . . . not really like physical science as in, you know, but not really that I can think of.

Q-32: *Okay. Would you want to teach someone else how to use either of these programs?*

A-32: Probably, that'd be cool.

Q-33: *Do you think you could?*

A-33: No. Probably.

Q-34: *Why do you say that?*

A-34: Well, I don't know . . . cause I'm not. . . like. . . I have trouble with . . . getting the right words out at times because I'm trying to think of the right word. . . the right way to say things so it would be hard to teach people anything because . . . just . . . it's hard for me to, you know, . . . like . . . so I put all these, you know, like . . . like getting the right words, so, but, besides that, you know, it wouldn't be that hard.

Q-35: *Okay. Is there anything else you want to add to anything we've talked about?*

A-35: Uhh, I like the concept of the Internet (chuckle).

Q-36: (chuckle) *Okay. Why do you like that?*

A-36: Because, you know, you can . . . meet new people and, you know, you don't have to . . . just . . . like you can talk to people through, well, the computer and talk to people away, far away, without spending as much money with . . . calling people, and you meet new friends in far off places, and, you know, like Ohio, or. . . (chuckle).

Q-37: *Okay, that sounds good. I think that's it. I'm going to go ahead and shut the tape off now.*













- Q-16: *Okay. Why would you say that?*  
A-16: It keeps the heat in. If you wrap it . . . if you wrap something in aluminum foil, it'll keep the heat in.
- Q-17: *Okay. Why does aluminum foil do that? Why do you think it does?*  
A-17: It keeps the heat in. If you wrap it . . . if you wrap something in aluminum foil, it'll keep the heat in so it doesn't escape.
- Q-18: *Why the aluminum foil? How do you mean . . . ?*  
A-18: 'Cuz I'm telling you, it wraps around so it prevents from making the heat come out, so it keeps it trapped.
- Q-19: *Okay, uhh, is there something . . . do you have a picture in your head or something you've seen that makes you think this is true?*  
A-19: Yeah.
- Q-20: *What is it?*  
A-20: Well, I've seen food. . . hot food in aluminum foil . . . wrapping it up and it still hot.
- Q-21: *Okay. Okay. I'll name another material now -- "wool".*  
A-21: Wool?
- Q-22: *Umm Hmm.*  
Q-22: Uhh . . .hot.
- Q-23: *Okay. Why do you say that?*  
A-23: Wool is big and heavy. When say people cold, you put it on but with wool on, it'll keep you warm.
- Q-24: *Okay. Is there something similar about wool and aluminum foil that they both keep you warm?*  
A-24: Yeah.
- Q-25: *What is that?*  
A-25: Well, aluminum foil doesn't keep you warm but wool does, sometimes.
- Q-26: *I'm going to name another material now -- "Styrofoam".*  
A-26: Uhh, cold.
- Q-27: *Okay, why do you say that?*  
A-27: Styrofoam wouldn't keep heat from . . . I think Styrofoam would cool it . . . (long pause) . . . Styrofoam wouldn't . . . Styrofoam wouldn't do either. It wouldn't keep it hot or cold.
- Q-28: *Okay, why not?*  
A-28: It doesn't have any effect on it. It's just paper-like. It doesn't "do" anything.
- Q-29: *What are the important things that it should do that it doesn't?*  
A-29: Uhh . . . uhh . . . it protects stuff like if you put something in Styrofoam, it won't break like when you dropped it.
- Q-30: *Umm . . .*  
A-30: It won't break. It protects stuff.
- Q-31: *Okay. Okay.*
- Q-32: *Now, what I'm going to do is, I'm going to ask you some stuff, something about computers.***  
A-32: Okay.
- Q-33: *Have you used computers a lot, a little, or . . . ?***  
A-33: A little.
- Q-34: *A little. Okay. I'd like for you to think about all the compeer software you've used and tell me what you think your favorite program is?***  
A-34: I like "Doom". I don't know the software name.
- Q-35: *What do you like about "Doom"?*  
A-35: Uhh . . . You have a gun and you run around shooting monsters.
- Q-36: (chuckle) . . . *is there . . . what are the sorts of things you like about "Doom"? I mean . . . what is it that makes this such a fun game, other than shotting monsters?*  
A-36: It's action between you and the racket and all that stuff.

- Q-37: *Okay. Did you? I'm going to show you a scale here. I was wondering if you could tell me which one of these best applies to "Doom"?*
- A-37: . . . (long pause) . . . the top.
- Q-38: *This one? Could you read that one?*
- A-38: *By the far . . . by far . . . by far the best I've used.*
- Q-39: *Okay. I was wondering. Did you like it the very first time you tried it or did it take a while to learn how to like it?*
- A-39: *No, I liked it.*
- Q-40: *Did you find it easy to play from the start?*
- A-40: *Yeah.*
- Q-41: *What was it that makes . . . what is it about it, do you think, that makes it easy to play?*
- A-41: *Maybe I'll get 'em.*
- Q-42: *(chuckle). I'm thinking of things like "switching guns" or "switching directions" or "going faster or slower" . . .*
- A-42: *I know what to do because I have played the games before. I know, you know, "where to go" and "what to do".*
- Q-43: *Okay. Is there anything that you don't like about Doom?*
- A-43: *It's not fast enough.*
- Q-44: *(chuckle) Okay. What . . . in what way?*
- A-44: *Well, the game goes slow.*
- Q-45: *Uhh huh.*
- A-45: *And when you walk it, it's too slow.*
- Q-46: *Okay.*
- A-46: *It needs to be faster.*
- Q-47: *Okay. Okay. Do you think this program would be of value to you in learning science?*
- A-47: *(chuckle) No.*
- Q-48: *(chuckle) Why not?*
- A-48: *'Cause you got a gun and you're running around shooting people (chuckle) and it has nothing to do with science.*
- Q-49: *Okay. Do you . . . would you want to teach someone else how to use this program?*
- A-49: *Yeah.*
- Q-50: *Have you taught anybody else?*
- A-50: *No.*
- Q-51: *No? Do you think you could?*
- A-51: *Yeah, I think so.*
- Q-52: *Why?*
- A-52: *It's easy when you tell somebody. If they know it . . . if they know what they're doing, you can tell them . . . tell them what to do and they'll . . . they'll know what to do.*
- Q-53: *Okay. Now, of all the stuff we've talked about today, is there anything that you wanted to add . . . anything about computers you want to add that I didn't ask you?*
- A-53: *Yeah. I got a computer at home. I like to use it, you know, typing homework and playing games and all of that. My friend, he . . . he . . . he . . . he's better. He knows the computer better than I do so if there be anything wrong, I ask him. Well, I guess, that's about it.*
- Q-54: *Okay. All right. I think we're done. I'm going to go ahead and shut the tape recorder off now. (CHANGE TO SIDE B OF TAPE 2)*

Interview Date: PRE  
Interview Number: 7  
Interview Protocol: (A)

(NOTE:.. Hi, this is Reuben and I'm going to review what my seventh interview of the day said because, like an idiot, I forgot to start the tape, which actually works out reasonably well because she probably wouldn't . . . she was kind of mumbling a lot anyway.

**Q-1: *When I gave her the "(A) Interview" on the construction paper, she really couldn't make a coherent sentence and she stated that she just couldn't get it.***

I asked her about "heat energy" and about "temperature" because those were two of the things that she had selected that looked like they were . . . that she thought were familiar to her and she saw the two as being different. She compared "heat energy" to "hot air" and "radiators" and "temperature" she knew was something that was more of a measure of how hot something was. She talked a little bit about "heat" and said that "heat" and "heat energy" were the same and that "cold" was the opposite of "heat", and that "cold energy" must be the opposite of "heat energy". She didn't have any real concrete examples on any of those beyond the radiator and, even after we finished, she never could construct a coherent sentence or statement about any of that.

**Q-2: *On the second question, about containers or wraps that help keep hot objects hot, whether they also keep cold objects cold, . . .***

. . . she said "yes". Her primary example was a "thermos" and she compared a "jar" and a "thermos" and said that if you put something in a jar and let it sit, it would cool off; but if you left it in a thermos, then it would stay warm. She said the same thing would happen if you put something cold in it, it would keep it cold. She didn't really know for sure what it was about the thermos that kept things hot or kept things cold -- part of it had to do with "keeping the heat in" or "keeping the cold in" and "not letting whatever was outside come in".

**Q-3: *Finally, on the question of computers,***

. . . her favorite software was *Claris Works* which she said was by far the best she had used. She liked it because of the variety of things she could do. She mentioned writing "stuff", making banners, pulling in pictures from other programs and putting them in your document and printing things out in color. She liked it from the very first time she tried it and it really didn't take long to learn how to like it. She thought it was a pretty easy program to use because you just start it up and start typing away. There wasn't really anything she could identify that she didn't like about *Claris Works*. She thought the program would be of value in learning science if it was used for writing reports. "Yes", she would want to teach someone else how to use it. In fact, she taught her little sister who successfully uses it. She considers herself someone who is able to teach someone how to use *Claris Works*.

I think that pretty much summarizes what she said in this interview.

- Q-1: *And, uhh . . . let's see, I think you're number . . . you're the eighth one that I've had for today. You're in good company. Why don't you come up a little closer. What this is, I've written out some phrases here and what I'd like for you to do is try and form a sentence out of this. You don't have to use all of these and if you need to use one more than once, just tell me and I'll give you a copy. What I'd like for you to do is form some kind of a sentence out of this that says something about science, about thermodynamics, that you agree with, something you find to be true, something you think is right, something you've seen . . .*
- A-1: Like what?
- Q-2: *Oh, maybe you've seen . . . you've thought a little bit . . . you've seen some of these terms like "heat energy" and "heat" and "temperature" and "cold" and "flowing" or maybe you've seen or noticed how things work with regard to "heat" or with regard to "temperature", how temperature moves up and down and what seems to happen with it. So, if you could just . . . if there's something in here that you can pull out, I guess, just to form a sentence. . .*
- A-2: How many do you pull out? One?
- Q-3: *Depends. Some people have got . . . used about three or four. Some have used about seven or eight. It all depends on what you see.*
- A-3: Any one of em?
- Q-4: *Yeah, just any order. Just make a sentence out of it so that you can read it.*
- A-4: . . . (short pause) . . . Hmm . . . well, mister, I don't know where to start.
- Q-5: *Well, here's some of these things here. Here's a place where you could start. Here's some other stuff you can use too.*
- A-5: . . . (short pause) . . . I don't know how to do this.
- Q-6: *Well, for example, can you think of things that generate heat or make heat or things that generate or make cold?*
- A-6: No.
- Q-7: No?
- A-7: Not really.
- Q-8: *Machines or anything like that? Or things that you use in your house?*
- A-8: Heaters. Stoves.
- Q-9: *Heaters. Okay, stoves. What do you know about . . . about heaters and stoves anyhow? What do they do?*
- A-9: Makes the whole house hot.
- Q-10: Okay.
- A-10: . . . temperature and stuff like that.
- Q-11: *Okay. How does it . . . do you know how they . . . well, let's go back here. What . . . when you see that word right here -- "heat energy", does that mean anything. What do you think of when you think of that word?*
- A-11: Hmm. It just make me hot.
- Q-12: *Okay. What about this one right here -- "temperature"?*
- A-12: . . . (short pause) . . .
- Q-13: *Have you seen this word before?*
- A-13: Yes.
- Q-14: *Well, what is it? What do you think about when you see it? Like I say, I'm not trying . . . just tell me what you think.*
- A-14: (chuckle) . . .
- Q-15: *Don't worry about being . . . you know, looking goofy or something like that. Just tell me what you think of it?*

- A-15: Uhh . . . (short pause) . . . I don't know. It depends on how, you know, how hot or how cold the room is, or whatever.
- Q-16: *Okay. Do you see these two as being the same or do you see them as being different?*
- A-16: Different.
- Q-17: *Okay. In what way?*
- A-17: Uhh . . . (short pause) . . . I don't know.
- Q-18: *What about if I were to bring up this little word -- "heat"? Do you see any of these as being the same or different?*
- A-18: "Temperature" isn't the same. I don't know.
- Q-19: *That's okay. Now tell me what you think. Don't worry about it.*
- A-19: Think about what?
- Q-20: *Is "heat" the same as either one of these?*
- A-20: "Heat" and "heat energy".
- Q-21: *Okay. You'd say that these are sort of the same thing?*
- A-21: . . . {inaudible} . . .
- Q-22: *Okay. What about "cold"? What would you say this would mean?*
- A-22: Freezing. Something like that.
- Q-23: *Okay. Do you ever think about why things stay hot and why things stay cold or why temperatures change, or anything like that? Do you see things, like at your house or at school or when you're out with your friends or something, where things stay hot or stay cold or get hot or get cold?*
- A-23: Outside . . . {indistinguishable} . . . it be warm and then be hot again . . . {indistinguishable} . . . and it start getting cool and stuff like that.
- Q-24: *Okay.*
- A-24: Sometime, at night it'll be hot and one time in my room when I'm going into the bathroom and it be cold and stuff like that.
- Q-25: *Okay. Okay. What about things like . . . I was thinking about a house . . . space heater in a house or electric heater (those little tiny ones that you plug in) or even an air conditioner or a refrigerator. What . . . do you know how those things work?*
- A-25: Electricity?
- Q-26: *Ummhmm. Okay. How does the electricity . . . do you know what the electricity does?*
- A-26: Make it work.
- Q-27: *Okay. Okay. What about this idea of . . . have you ever heard of the idea of "heat flow"? When you hear the . . .*
- A-27: Flowing around the room or something like that.
- Q-28: *Okay. So, when you think of "flowing", you think of like "air moving around"?*
- A-28: . . . {inaudible} . . .
- Q-29: *Okay. I think what I'm going to do is . . . thanks . . . is there anything else that you wanted to add (I should say that) ?*
- A-29: . . . {inaudible} . . .
- Q-30: *Okay. Well, I'm going to fold these up and put these away. I'm going to ask you another question . . .*
- Q-31: . . . and that question is, now, do containers or wraps that keep hot . . .**
- A-31: What?
- Q-32: Containers or wraps - a container or a wrap that you wrap around something - do the containers or wraps that you could use to keep something hot also be used to keep something cold?**
- A-32: Can you repeat that?
- Q-33: Yeah. If you had a container or wrap and you use it to keep something hot, could you use that same container or wrap to keep something cold?**
- A-33: I don't know if you can.
- Q-34: *Okay. What would it depend on?*

- A-34: On how hot or cold it is.
- Q-35: *How hot or cold the thing you want to keep . . .*
- A-35: Umm Hmmm.
- Q-36: *Can you think of something that people use to keep things hot or to keep things cold?*
- A-36: A thermos, a freezer or refrigerator, or something like that.
- Q-37: *Okay. Do you know or do you have an idea what a thermos does to . . . to do . . . to work . . . how a thermos works?*
- A-37: Hmmm . . . sort of like coffee, tea, or something like that?
- Q-38: *Umm Hmmm. Yeah.*
- A-38: Water.
- Q-39: *Do you know how it works?*
- A-39: You go plug it . . . well, the one that we got at home, you can plug that one up. Nancy, she got one you don't plug that one, you just turn it on. . . {indistinguishable} . . .
- Q-40: *Umm Hmmm. Okay. Now, what about for keeping things cold. Could that thermos be used to keep something cold?*
- A-40: I don't know. Maybe if you put ice in it, I don't know. I guess you can put ice in it.
- Q-41: *Okay, can you think of other things that people use to keep things hot or to keep them cold?*
- A-41: Umm Hmmm. An electric blanket.
- Q-42: *Okay.*
- A-42: That's all.
- Q-43: *Okay. What about . . . I know some people talked about seeing foods at restaurants and sometimes they're wrapped in stuff. Did you ever notice that?*
- A-43: Cakes and stuff, don't they?
- Q-44: *Umm Hmmm. What about things that are hot or things that are cold that are wrapped up? Like baked potatoes? Sometimes they wrap those?*
- A-44: It be hot some. It be hot.
- Q-45: *Okay. All right.*
- Q-46: *The last thing I want to talk about is computers. Okay, we've had a couple of questions about science? I want you to . . . how much have you used the computer?***
- A-46: I just started using the computer this semester but I never had any last semester. I just started on it this year.
- Q-47: *Okay, so think about all the software that you've used this year?***
- A-47: Umm Hmmm.
- Q-48: *The software? The programs? And tell me which one you think you like the best. Which one is your favorite?***
- A-48: Out of what?
- Q-49: *Out of all the ones you've used. Anything.*
- A-49: Like Computer Technology . . . {indistinguishable} . . . that's the best one I like. Apple Share and stuff like that.
- Q-50: *Apple Share? What about . . . what is Apple Share?*
- A-50: There's, uhh, one program on Mr., uhh, Date's computer, there's one program talking about . . . talks about a lot of stuff, how you use computers and stuff like Professor Mac and stuff like that.
- Q-51: *Umm. Okay.*
- A-51: It's . . . {indistinguishable} . . . unless you . . . {indistinguishable} . . . the action.
- Q-52: *Okay. And what is it that you are able to do with that?*
- A-52: Hmmm?
- Q-53: *What can you do with that? How do you use that?*
- A-53: Use what?
- Q-54: *Apple Share. When you're using that?*
- A-54: The only thing you can do is read and answer the questions.
- Q-55: *Okay. So, this is . . . it's kind of a little program that tells you how to use Apple Share?*



- A-55: Yeah, on the computer and stuff like that.
- Q-56: *Now I'm going to ask you, this program that you use, of these four statements that I have written there, which one do you think would best apply to this one that you told me about?*
- A-56: . . . (long pause) . . . This one.
- Q-57: *This one down here? Okay. That's "this is the only one I've ever used". Okay? Uhh, do you feel that this program that you've used is easy to use?*
- A-57: Not really. Some of the questions in there is hard and some are in between hard and easy. You can put it on different levels.
- Q-58: *Oh, really? Okay. Do you find it easy to work the program?*
- A-58: Yeah.
- Q-59: *What is it that you have to do to make the thing work?*
- A-59: There's a little button on it that you can push and you can put it on "easy", "hard", or whatever and then you just move the mouse around and click on either one you want. Sometimes, it'll be a true or false. Sometimes, it'll be multiple choice.
- Q-60: *Okay. Did you like it the very first time you tried it or did it take a while to learn how to . . .*
- A-60: Yeah, it took a while.
- Q-61: *It took a while? Okay. What did you think about it the first time you used it?*
- A-61: I thought it was, uhh, hard for a minute and then after you showed me how to work the computer, I was getting better sometimes . . . but it was hard at first.
- Q-62: *Okay. Is there anything that you don't like about it?*
- A-62: Hmm m?
- Q-63: *Anything you don't like about it?*
- A-63: Too many questions (chuckle).
- Q-64: *Too many questions? (chuckle). Okay. Do you think this program would be of any value to you in learning science?*
- A-64: What program?
- Q-65: *For what? Yeah, this one we're talking about.*
- A-65: (Sigh). Kind of.
- Q-66: *How so?*
- A-66: I don't know (chuckle).
- Q-67: *(chuckle) Okay. Do you think you'd want to teach someone else how to use this?*
- A-67: To use what?
- Q-68: *This program that we're talking about.*
- A-68: This hard one?
- Q-69: *Yeah, the one . . .*
- A-69: Umm Umm (no). I don't know.
- Q-70: *Have you ever tried to show someone? I mean, you know, they showed you how to use it . . .*
- A-70: Yeah, I help people out in the classroom that need help but, you know, they tell us that we can, you know, . . . show with our hands. We can tell them but we can't show them what to do and nothing like that or like just tell 'em how to use it, or whatever.
- Q-71: *Okay.*
- A-71: And let them learn on their own.
- Q-72: *Okay. You think that makes sense?*
- A-72: Yeah.
- Q-73: *Okay. Do you think you could teach somebody, though?*
- A-73: Umm. A little bit.
- Q-74: *Okay, now of all the stuff I've asked you . . .*
- A-74: The stuff I know.
- Q-75: *The stuff you know.*
- A-75: Yeah.
- Q-76: *Okay. Now, of all the stuff I've asked you . . . of all the questions I've asked you, is there anything about computers that I didn't . . . that we didn't cover, that you want to tell me about?*

A-76: . . . Uhh Uhh (no) . . .

Q-77: *Okay. All right. Well, I think we're probably done. I'm going to go ahead and shut the tape off now*

Q-1: *This is, believe it or not . . . this is the 9th interview that I've done today so you've been in good company. What I've got, first of all, is I've got these phrases and words and stuff and what I'd like for you to do is to make a sentence out of this that you would agree with. So, just anything . . . if you can make a sentence out of these words and the sentence just has to be something that you would agree with, that you think is true, that you think is a fact of some kind . . . (short pause) . . . I notice someone left out a couple of them. I've got a couple more here.*

A-1: . . . (short pause) . . . Objects . . . at . . . higher and . . . no . . . higher temperature.

Q-2: *Okay, can you read that whole sentence again?*

A-2: Heat flows around objects at higher temperature.

Q-3: *Okay. Now, can you tell me what it is about that, that you agree with?*

A-3: Like, uhh . . . not really.

Q-4: *(chuckle)*

A-4: I just thought up of something.

Q-5: *Okay. Do you think that's true?*

Q-5: A little bit of it.

Q-6: *Okay. What part of it is true?*

A-6: The, uhh, heat flowing around. The high heat circulates around . . .

Q-7: *Ummhmm.*

A-7: Around the, you know, the object at a higher temperature. I just thought it sound right.

Q-8: *Okay.*

A-8: But heat flowing around, you know, how heat circulates, and . . . rises when it gets hot . . . it rises . . . and stuff like that, so that's probably the only true part of the sentence.

Q-9: *Okay. Okay. Now, you were comparing . . . you were just now making a motion like something going around a room like . . . ?*

A-9: Like . . . sort of like . . . like an orbit. You know, like on the moon, like when the planet goes around the sun, how when it like gets hot, the heat it starts circulating around the whole room and it fill the whole room up with warm air instead of just like coming out . . . and coming out straight, you know, out of the sides. It circulate around the whole room like one big wide orbit and it just keeps going around until it fills up the whole room.

Q-10: *Umm. Okay. What about this word right here -- "temperature"? What do you think of when you see that word?*

A-10: Uhh. I think of thermostats, temperatures on the thermostats, and outside temperatures and stuff like that. Numbers mostly. That's about it.

Q-11: *Okay. Now, once more I want to ask you about "heat" -- what you thought heat was?*

A-11: It's like, uhh, "warm". Uhh, now, let me see here. It's warm air. Heat is just like . . . it don't necessarily have to be warm air but like heat from the sun and stuff like that, and all that, just . . . I don't know.

Q-12: *Okay. Do you think that "heat" and "temperature" are the same, or do you think they're different?*

A-12: They're the same. Well, they're almost the same. Like, temperature . . . if you think of temperature, like . . . {indistinguishable} . . . would probably say more like numbers. Heat, it would be like warming up the place, like I just said and stuff like that but basically, it's about the same.

Q-13: *Okay. Okay. Is there anything more you want to add about any of this stuff?*

A-13: . . . (short pause) . . . Uhh uhh (no).

Q-14: *Okay. Okay, that's good. What I'm going to do is I'm going to collect all of these and put them down here and I'm going to go on to the next question that I want to ask you . . .*

**Q-15:** ... *and that is, do containers or wraps that help keep hot objects hot also keep cold objects cold?*

A-15: It depends. Like, there's some kind of objects are just made where they just keep the warm air in but they make containers like that keep hot . . . hot stuff hot and cold stuff cold, but basically, almost all . . . almost all objects . . . like if you put it in a mug . . . you pour some coffee in a mug, it'd stay hot. The mug would keep it hot. But if you put some Kool Ade in it, for instance, I think it'd keep it cold too.

**Q-16:** *Okay. You talk about a mug. Have you seen this happen before? Are you familiar . . . Do you have a mug that you've seen this done before with?*

A-16: Yeah. Over at the gas station that's produced, on the commercial, like if you fill up the gas and you get this free cup . . . like when you go to the races, you can put your drink in it and it'll keep it cold for like that period of time that you're drinking and if you put hot stuff in it, it'll keep it hot.

**Q-17:** *Hmm. Okay. Now, do you know what it is about that mug that would make it work like that?*

A-17: Umm Umm (no).

**Q-18:** *Can you imagine what . . . how that mug might work like that?*

A-18: It's probably some kind of, uhh . . . (short pause) . . . because it's glass instead of plastic. You know how glass be cold . . . ughhhh . . . that's not it . . . I'm speechless.

**Q-19:** (chuckle) *Okay.*

**Q-20:** *Let's go ahead and talk about computers now, okay?*

A-20: Great.

**Q-21:** *You like that, huh? Okay. How long have you been using computers?*

A-21: Like since elementary . . . about the second grade is when I learned to use the computers.

**Q-22:** *Okay. Now, I want you to think about all the different computer software that you've used over the years, okay? And I'd like for you to try and tell me which one is your favorite?*

A-22: Oh, when we did the great ocean rescues . . . was it the seventh grade? Yes, it was in the seventh grade. It was in Mr Tool's (spelling?) science class. It was a thing where they sent you on a ship and they send you out and they tell you what you gotta find. You use sonar and you dive in, with sharks and stuff in the water, and you got light and some kind of electric thing where you put it up to them and you gotta go out and find like a hump-backed whale and then you gotta use sonar and then you look and they show you how deep the water is, or they'll have a little image of what's in there and they have your picture taken for about fifty dollars or a hundred dollars. But you only got a certain amount of time and when you run out of time, you see, the game's over.

**Q-23:** *Hmmm.*

A-23: Then you got to start all over again.

**Q-24:** *Hmm, okay. I'm going to show you this scale here and if you could just pick out which one of these describes that software that you chose . . . (Short pause) . . . this one? Could you read that?*

A-24: By far the best I've used.

**Q-25:** *Okay. Now, did you like this the very first time you tried it or did it take you a little while to learn how to like it?*

A-25: Well, I liked it the first time I played it 'cause I like doing stuff where you gotta work a little and you gotta think, instead of it just being like real easy and you already know what you're going to do before you just start.

**Q-26:** *So, did you consider this to be an easy thing or did it take a while?*

A-26: I considered it easy.

**Q-27:** *Did you ever actually get to use the software itself? Did you get to move the mouse or do anything like that . . . "*

- A-27: Oh yeah, I moved the mouse and everything, you know, and all that. I typed the answers and stuff like that.
- Q-28: *Okay. So, you seemed to figure out how it went? Okay. Was there anything you didn't like about it?*
- A-28: Oh, that software that I played on? Nothing. Really, the whole program's fun.
- Q-29: *Okay. Were there . . . you told me some things you liked about the challenge and not doing things that are too easy. Was there stuff about the software itself that you thought you really liked?*
- A-29: U . . . h . . . h, yeah. There was stuff about it . . .
- Q-30: *I'm talking about how it was put together.*
- A-30: Oh, I really never think about it like that. I usually just pop it on in and play it. I never go the "extra two yards" to think about how its made and stuff but really, I really never thought about that.
- Q-31: *Okay. Umm. Now, do you think that this program would be of value to you in learning science?*
- A-31: . . . {inaudible . . .}
- Q-32: *How so?*
- A-32: Well, it's like it's got a wide variety of things that you could do, like working with electronics and stuff like that. It would sort of help me like how to read stuff because you know, going through the water stuff, touching stuff, like if you touched the jelly fish, you would die and stuff from the poison, and it was sort of like a learning thing. It'd teach you the stuff not to touch when you're in the water, or stuff you can, such as you can't go down too deep or your stuff will crack or stuff like that.
- Q-33: *Hmmm. Okay. You seem to remember it pretty well, considering you did it last year. Would you want to teach someone else how to use this program?*
- A-33: Aghh. Yeah.
- Q-34: *Do you think you'd be able to teach them?*
- A-34: Umm Hmmm.
- Q-35: *Why? Why do you think you'd be able to do that?*
- A-35: 'Cause I really got . . . I really got the basic understandings of it. It's like once I get something where I could do it, like from front to back and back to front, it's real easy for me to explain to somebody, like I like doing the model cars and I can just like sit somebody down and just show them how to read the directions and look for the numbers and stuff and put it together and if they just work at it a little while, you know, it's easy to teach somebody how to do it.
- Q-36: *Hmmm. Okay. Is there anything else, of all the things we've talked about computers, is there anything else about computers that we didn't talk about that you want to tell me about?*
- A-36: Aghh. Umm Umm (no), not that I can think of.
- Q-37: *Okay. Well, I think we're done. I'm going to go ahead and shut this off now, okay?*

- Q-1: ... *You've got lots of company ahead of you. What I'm doing is I'm putting out these little words right here and what I'd like for you to do is to look at these and try and make a sentence out of this that you would agree with, or a sentence that you think makes sense ... a sentence that ...*
- A-1: Out of all these words?
- Q-2: *Yeah. Well, you don't have to use them all. You can just use a few of them. You could use them all if you want to and if you see one that you want to use twice, let me know and I'll give you a copy of it. . . but just something you agree with ... and take your time.*  
... (long pause) ... *You can think out loud if you want.*
- A-2: ... (long pause) ... I don't know if this is right.
- Q-3 *That's okay ... (long pause) ... Is there something you're wishing was here that isn't here?*
- A-3: ... (short pause) ... I don't know. This is frustrating.
- Q-4: *Well, let me ask you. What are you trying to make right here when you say this? Can you read what you have down so far?*
- A-4: Temperature flows out of objects that ...
- Q-5: *Okay. What are you ... what's sort of "behind" what you're trying to say right here?*
- A-5: I don't know.
- Q-6: *Okay. What does this word mean to you -- temperature?*
- A-6: Well, like, uhh, how like hot or cold something is.
- Q-7: *Okay. Now, let me ask you this. Would you say that this right here "heat energy" is the same or different than "temperature"?*
- A-7: ... (short pause) ... I guess it's the same.
- Q-8: *Okay, what would you ... I mean, could you define what you think "heat energy" is?*
- A-8: I don't really know what it is.
- Q-9: *Okay, what about if I bring this word over -- "heat". Could you tell me what you think that is?*
- A-9: Like, how hot something is. Heat is like hot.
- Q-10: *Okay, if you had to describe "hot" to somebody, what would you say?*
- A-10: ... (short pause) ... Hot is something that. . . burns.
- Q-11: *Is there something you have in your head, or a picture you have in your head, when we're talking about "heat" and "hot" and "temperature" and "things like that"?*
- A-11: Yeah, when I was thinking about "heat", there was like a pot on the st ... a pot of water on the stove ... like boiling.
- Q-12: *Where would be the heat in that picture?*
- A-12: The fire coming up from the stove and heat in the pan ...
- Q-13: Okay, is there any temperature ... ?
- A-13: ... keeping it hot.
- Q-14: *I'm sorry, go ahead ... is there any temperature in that picture you're talking about?*
- A-14: The water's a certain ... a certain temperature.
- Q-15: *Okay, and what about "heat energy"? Is there any "heat energy" in that?*
- A-15: I don't even know what "heat energy" is.
- Q-16: *Okay. Okay. Is there anything else you want to say about any of this that I haven't asked you?*
- A-16: ... (short pause) ... No.
- Q-17: *Okay. Well, what I'm going to do is ... I'm going to go ahead and slide these off to the side now and I want to ask you another question.*

**Q-18:** *What I want to ask you is... do containers or wraps that keep things hot also keep things cold?*

A-18: ... like ... stuff ... like ... holds ice water and stuff?

Q-19: *Umm Hmmm.*

A-19: ... like thermal jugs?

Q-20: *Sure.*

A-20: *Yeah.*

Q-21: *Okay, now what is it that makes you say that... that it's "yes"?*

A-21: *Because sometimes ... like ... uhh ... I put ice water in it and sometimes I ... like ... put hot chocolate and it stays hot and cold.*

Q-22: *Okay. Hmmm, so this is something you've done before? Do you have any idea why that thing works that way?*

A-22: *No.*

Q-23: *Okay. Do you have a guess? Do you want to try and guess?*

A-23: *The heat and the cold just stay in there.*

Q-24: *Stay in ... ?*

A-24: *.. the ... jug.*

Q-25: *Okay. Do you ... can you think of another example ... besides this one you mentioned? Is there another container or wrap that works?*

A-25: ... (long pause) ... No.

**Q-26:** *Okay. Okay. What I want to do... I've asked you a couple of questions about science. What I'd like to do now is to ask you questions about computers, okay? How often or how much have you used computers?*

A-26: *I had a computer class last quarter for nine weeks and my friend ... he's got a computer so I play ... like ... computer games over at his house.*

Q-27: *Okay. What I'd like for you to do is to think about all the computer programs that you've used in your whole life and tell me which one you would say is your favorite?*

A-27: *What do you mean by program, okay?*

Q-28: *Software.*

A-28: *Like Kid Pix?*

Q-29: *Yeah. That's a program. That's right.*

A-29: *I don't really know because I don't know that much about computers, really.*

Q-30: *Okay. Well, let me ask you... of these four, would you... well, of these four, would you say that this is... if you've only used one, or pretty much all the ones you've used, are about the same? Nothing really sticks out?*

A-30: ... (short pause) ... I don't know. There's ... We play ... like ... games on my friend's computer but I don't like know what program it is... like.

Q-31: *Okay, is there any particular game that you really like?*

A-31: *Mega racers, or something like that.*

Q-32: *I don't think I've seen that one yet. What is it that you like about it?*

A-32: *It's got cool graphics and the guy talking 's pretty cool.*

Q-33: *Oh, yeah... why is that?*

A-33: *He's really funny. He don't know how to talk. (chuckle)*

Q-34: *(chuckle) Okay. Is it an easy game to play? I mean, do you know ... I'm not saying, is it hard to win the race, or do you have to win a race?*

A-34: *Yeah, you gotta like ... shoot at like cars.*

Q-35: *Okay. What I'm asking is, is it easy to figure out how to shoot the cars and how to move the car and how to steer and how to stop.*

A-35: ... {inaudible} ...

Q-36: *Okay. You're nodding "yes", just so the tape player knows.*

A-36: *(loudly) Yes.*

- Q-37: (chuckle) . . . Okay. Now, did you like this game the very first time you played it or did it take a while to learn to like it?
- A-37: It like took a few days because the first time I felt like dying (chuckle). It's like running into the walls and stuff.
- Q-38: Okay. Is there anything that you don't like about it?
- A-38: . . . (long pause) . . . Nope.
- Q-39: Okay. Now, do you think this program would be of value to you in learning science?
- A-39: No.
- Q-40: No? Why not?
- A-40: 'Cause it's just fun, like of like . . . (indistinguishable).
- A-41: Okay, would you want to teach someone else how to use this program?
- A-41: Would I?
- Q-42: Umm Hmm .
- A-42: I don't know. My friend, he just like sets it up for me and then I start to play.
- Q-43: Umm Hmm.
- A-43: So, I'm not really like using the mouse to like go into the game. I'm just . . . I just start playing the game.
- Q-44: Okay. . . go ahead.
- A-44: That's okay, that's all.
- Q-45: Okay. I guess that's. . . let's see, is there anything else about computers that you haven't mentioned or we haven't talked about that you want to tell me about?
- A-45: No.
- Q-46: Okay. Well, I think we're probably done then. I'm going to go ahead and shut off the tape recorder, okay?
- A-46: All right.



- Q-1: *I'm going to start the tape recorder.*  
A-1: All right.  
Q-2: *This is, believe it or not, Interview Number 11 for today.*  
A-2: Oh.  
Q-3: *And the first thing I'm going to ask you to do is . . . I've got these little phrases here on these papers . . .*  
A-3: All right.  
Q-4: *And what I'd like for you to do is try to form . . .*  
A-4: A sentence?  
Q-5: *A sentence. That's right. A sentence that . . . not just any sentence but I really want it to be a sentence that you agree with, or a sentence that you think is true, a sentence that you've seen before.*  
A-5: . . . (long pause) . . .  
Q-6: *Let's see. You don't have to use all of them.*  
A-6: Ummhmm.  
A-7: *If you just want to use some of them, that's fine. I forgot to tell you that and I also have duplicates, if you need a copy of one of these, just let me know.*  
A-7: . . . (long pause) . . . Do you have a "the"?  
  
Q-8: *You can pretend there is a "the" there.*  
A-8: . . . (long pause) . . . This is dealing with "heat"? This is dealing with heat, right? Or just plain temperature like?  
Q-9: *Deal with either one, or both.*  
A-9: . . . (long pause) . . . here's what I've got.  
Q-10: *Okay, do you want to go ahead and read that?*  
A-10: . . . (long pause) . . . can we add "as" to it too?  
Q-11: *Sure.*  
A-11: . . . (short pause) Well, what I can make the best out of it is "heat energy flows into objects at the same temperature as cold energy".  
Q-12: *Okay. . .*  
A-12: I can't make a better sentence.  
Q-13: *Okay. Can you tell me why you agree with that or why you think that's true?*  
A-13: Well, because, if we would ask. . . if we would put these. . . if we would put . . . try to put these into a . . . in another kind of sentence, it wouldn't make no sense, but you may be able to put . . . to make a sentence out of this but I doubt it.  
Q-14: *Okay. What is the idea that you're trying to get across with this?*  
A-14: Hmmm. That's what I'm trying to say. It isn't easy. . . (short pause) . . . Wait now . . . Do you have a "rate" in this?  
Q-15: *We can pretend there is a "rate" to it.*  
A-15: All right. Let's put it like this. Heat energy flows into object at a higher rate temperature than cold energy.  
Q-16: *Okay. Did you say "higher rate"? What's this word in here? "Higher rate"?*  
A-16: Than the cold energy . . . I mean . . . than the, than the cold energy . . . wait a minute . . . than the cold energy.  
Q-17: *Okay, so it's "Heat energy flows into objects at a higher rate than cold energy"? Okay. Now, why do you think that's true?*  
A-17: Because I was thinking that . . . different . . . like . . . let's see. Most of the times if you had a jar of cold energy, most of the times something cold 'cause you have to deal with it some to get it perfectly heated up. So, I'll just say if. . . instead of saying it like if you're in a car

and you put hot air into the car, then it will dominate the car much faster than cold energy.

Q-18: *Now, tell me again what you think "heat energy" is?*

A-18: Heat energy could be a whole bunch of stuff. It could be fire. It could be just plain . . . warmth from outside, or it could be . . . it could even be electricity at some point in time.

Q-19: *Okay, what about "cold energy". What are you calling that?*

A-19: Well, that's a whole bunch of stuff. It could be like. . . if you melt it down, it could turn to a . . . like . . . a gas and make everything cold. That's what I'm trying to make a point. Cold energy is like a gas that makes everything cold and you hit the cold energy with heat energy, most times . . . umm, nine times out of ten, the heat energy is going to win.

Q-20: *Hmmm, okay. Why do you say that?*

A-20: Just because . . . why . . . because in the snow. Like, when you came in here. . . even if we had like. . . if in this room, it was all cold in here and even if we had one little bitty vent in here with heat air coming out, you'd probably think that it would turn warm in here in a matter of . . . in a matter of time.

Q-21: *Okay. Okay. What about this . . . this phrase here "flows into"? What does that . . . what does that mean?*

A-21: I was thinking that it would flow into the object that I'm talking about.

Q-22: *Umm Hmmm.*

A-22: The heat energy flows into the hot. . . the object that I'm talking about.

Q-23: *Yes, what I'm saying is, how does heat energy flow? Where does that heat energy flow from?*

A-23: Oh, like it's going into the object. That's what I'm trying to say. It's going into the object.

Q-24: *Okay. Okay. How does it go into the object?*

A-24: Are you talking about what tool, or just how does it basically go in there?

Q-25: *Umm Hmmm.*

A-25: How does it basically go in there?

Q-26: *Umm Hmmm.*

A-26: Well, I guess. . . All right, this is the object and this is a vent. The heat is just gradually just going into the object. Even if it's covered, some of the heat will go into . . . will eventually go inside this object.

Q-27: *Umm Hmmm.*

A-27: And run. . . and that's what I'm trying to say.

Q-28: *Okay, now I'm just doing this for the tape recorder. While you were doing that, you had your hand open and left a little hole . . . and formed a little hole with your hand and you were passing your other hand over it, like that, to show that some of it was going into the hole and some of it was passing over it. Okay, that's just for the tape, so I know what you were doing with your hand here. Okay, what I'm going to do is . . . I'm going to take these off the way now and . . .*

Q-29: *. . . I'm going to read to you another little question. I'm going to name a material and I'd like for you to tell me if you would use it for keeping something hot, keeping something cold, both, or neither. Okay? First material is aluminum foil.*

A-29: Hmmm. Neither.

Q-30: *Okay, now, why do you say that?*

A-30: Well, basically, that's what I use it for because when I put something in aluminum foil, I'm mostly, . . . so, if you leave it out . . . well, I'll say, keep it cold.

Q-31: *Okay, go ahead.*

A-31: "keep it cold" because . . . like . . . you could use something else 'cause when I get something, like food, when I'm over at my grandparents' house, I usually put it in aluminum foil so I can put it in the refrigerator and it seems like, once the cold air goes into the Reynolds Wrap, it keeps it . . . the cold air flows around the Reynolds Wrap. It keeps it cold. But it could also work for heat, I think.

Q-32: *Why do you say that?*

- A-32: 'Cause it could work the same way. If it was heat around it, it could do the same thing . . . 'cause it would be hot on the surface.
- Q-33: *Okay, so do you want to change your answer?*
- A-33: I'll go with "cold".
- Q-34: *Okay. Okay. Another material -- "wool"?*
- A-34: Wool. It keeps yourself hot.
- Q-35: *Okay. Why do you say that?*
- A-35: Because mostly . . . if you . . . you go to a . . . mostly, if you're like in a blizzard, you keep yourself -- you see, I mostly make examples -- you will want to keep yourself. . . 'because you will always . . . you will . . . because, if you like, this is kinda hard. If you keep . . . if you put something on your body to keep yourself warm.
- Q-36: *Umm Hmmm.*
- A-36: That's basically what it is. Anything . . . anything you put on yourself -- a sweater -- is to keep myself warm. That's mostly basically what it is.
- Q-37: *Okay, do you know why wool?*
- A-37: Why would you use wool?
- Q-38: *Yeah.*
- A-38: Some . . . 'cause it's a lot more warmer than other materials.
- Q-39: *Okay. Let me give you one more material -- Styrofoam.*
- A-39: Styrofoam. Well, the only . . . the only thing I know for Styrofoam is when you get something new, it's able to keep your package from not getting damaged.
- Q-40: *Umm Hmmm.*
- A-40: If you have it in a box. It keeps it from not getting damaged.
- Q-41: *Okay. So, what about for keeping things hot or cold?*
- A-41: Oops, I forgot about that. Oh yeah, to keep things hot or cold, it would keep things hot.
- Q-42: *Okay. Why do you say that?*
- A-42: I'm saying that because mostly the box will keep the uhh . . . keep the uhh . . . the rains off of it but the Styrofoam . . . it'll probably cover it but I don't think it will hurt it but the heat would . . . could melt the thing inside the box because the box gets so warm. If it wasn't there for the . . . if the Styrofoam wasn't there to keep the warm box away from it, it could do some damage to it.
- Q-43: *Okay. Do you see something similar between "wool" and "Styrofoam"? You said they both keep something hot. Is there something that's the same about them that would do that?*
- A-43: They both protect something. They protect your body and they both. . . they both protect something . . . protect something from getting harmed. 'Cause even if you have wool on, that's protecting your body.
- Q-44: *Okay. Okay, I think that's it.*
- Q-45: *Let's go ahead and talk a little bit about computers now.***
- A-45: All right.
- Q-46: *How much do you use computers?***
- A-46: Sometimes. Not as much as I used to.
- Q-47: *Okay. I'd like for you to think about all the different computer software that you've used over the years. . .*
- A-47: All right.
- Q-48: *And tell me what you would consider your favorite program to be.*
- A-48: Hmmm. . . What is it? *Prodigy*.
- Q-49: *"Prodigy"?*
- A-49: Umm Hmmm.
- Q-50: *Okay, Can you. . . What exactly do you like about "Prodigy"?*
- A-50: You can call people. . . and you can do a whole bunch of stuff with it.
- Q-51: *Oh, yeah. . . like what?*
- A-51: Call people. If somebody has a computer, that's what I mostly like, you can talk to them.

- Q-52: *Umm Hmm.*
- A-52: You don't even have . . . They don't even have to know who you is. You can talk to them on the computer. You can even call in to this computer and learn the weather, everything.
- Q-53: *Hmmm. Okay. I'm going to show you a scale, okay, and I'd like for you to tell me which one of these would best describe this piece of software that you told me about.*
- A-53: . . . (short pause) . . . put a check on it?
- Q-54: *No, just tell me or read it.*
- A-54: This one. This one. I picked this one as the best but I did think about other ones.
- Q-55: *Okay.*
- A-55: There's other ones I like because I like to draw or something.
- Q-56: *Umm. . . Okay. So, let me ask you this, did you like "Prodigy" from the very first time you used it or did it take a while to learn to like it?*
- A-56: I liked it the very first time . . . well, the very first time I used it.
- Q-57: *Okay. Do you think it's easy to use?*
- A-57: It takes some time to get used to it.
- Q-58: *Did it take you a while?*
- A-58: A little while.
- Q-59: *Do you still . . . do you think it's easy now?*
- A-59: I'd have to get used to it again.
- Q-60: *Okay, you haven't used it for a while?*
- A-60: *Umm Hmm.*
- Q-61: *Okay. You told me (CHANGE TO SIDE B OF TAPE 3. Transcriptionist note: There are rather loud background noises on tape.) some things that you did like about it? Was there anything about "Prodigy" that you didn't like?*
- A-61: Well, it was. . . it wasn't that . . . you know . . . lucky . . . {indistinguishable} . . .
- Q-62: *Okay. Now, do you think that this program would be of value to you in learning science?*
- A-62: In learning science?
- Q-63: *Umm Hmm.*
- A-63: . . . {indistinguishable} EMS Computer.
- Q-64: *Okay, how would that be valuable?*
- A-64: So, let's say you would be doing something about the weather and you could just dial up the EMS computer. Then maybe I could go into the computer and it'd tell us everything we need to know about the weather. . . what the prediction of the weather.
- Q-65: *Okay. Would you want to teach someone else how to use this program?*
- A-65: It would be kind of hard.
- Q-66: *Why would it be hard?*
- A-66: 'Cause I haven't did it a lot but I think I probably could, but now it's starting to get a little bit harder.
- Q-67: *Okay. You think you could have done it. Would you have "wanted" to do it?*
- A-67: I don't know. Probably if I took someone by myself. Like a little kid. I'm so into it myself. I never really think about that.
- Q-68: *Umm Hmm, okay. Now, of all the stuff we've talked about computers so far, is there anything that we haven't talked about that you want to mention about computers?*
- A-68: I like the CD's on it.
- Q-69: *Oh yeah? Why is that?*
- A-69: 'Cause you can do a whole bunch of stuff with a CD. You can do anything from music to robots coming to life. . . you know, like computer energy. . . imaging too . . . that's what I want to do when I grow up.
- Q-70: *Oh really? What is computer imaging?*
- A-70: Have you ever seen . . . You ever seen *The Terminator* movie?
- Q-71: *Umm Hmm.*
- A-71: That's computer . . . its called, uhh, computer generated imaging. You seen *The Terminator* movie?

Q-72: *Umm Hmm.*

A-72: You know when he got . . . when he was like . . . got, uhh, when they shot him, before he went in there, that's what they had to do.

Q-73: *Hmmm. Okay. I see what you're saying. And you'd like to do something like that?*

A-73: *Umm Hmm.*

Q-74: *Why is that?*

A-74: Seems fun. I really get into that kind of like movies like that. They can stretch an arm out way out over there and make it go around the computer and come right back here. Then, it can go back around and come back until it is beyond the building. Or, he can get his arm cut off and he can pick it up and put it back on.

Q-75: *Okay. All right. Sounds good. Well I think we're done. I'm going to go ahead and shut the tape off now.*

- Q-1: *(Transcription Note: The tape was turned off but the following is the essence of the question that was asked) I have some phrases written on construction paper. I would like for you to arrange these phrases so that they make a complete sentence that you believe to be true. You can use a phrase more than once for the sentence; just ask and I will give you a copy. I guess I should turn the tape on. Now the tape's on. You can go ahead and start.*
- A-1: Ohh . . . (chuckle) . . . Heat . . . (short pause) . . . I say heat. . . I don't know . . . I don't know, really, it would be like. Wow. I wish I could prepare for this. . .
- Q-2: *That's okay. I guess I'm just looking to see what you think about it.*
- A-2: It's like, well . . . Temperatures . . . temperatures come like cold, like hot. You ain't got "hot", you've got "heat".
- Q-3: *If you want to make that hot, that's okay.*
- A-3: You can have lower air pressure, or higher, or something like that. . . I really don't know about this (chuckle).
- Q-4: *Let me ask you this. Why did you choose "heat" and "temperature" right off the bat?*
- A-4: Because heat is a temperature (chuckle).
- Q-5: *Okay. So, do you see them as being different or the same?*
- A-5: The same.
- Q-6: *Okay.*
- A-6: Because we're talking about heat. It's a temperature. Like you know, if it's hot outside. . . I mean, like if it's heat, like heating a home living room, you can turn the heat up to 80 or something like that, so it's a temperature.
- Q-7: *Okay. I'm curious. If I were to put this guy over here that says "heat energy", would you say that was the same as those or would you say it was different?*
- A-7: Heat energy? I'd say it was different because like that's energy of the heat and it wouldn't be the same as the heat, I don't think (chuckle).
- Q-8: *Okay. What would you call . . . I mean, if you had to describe heat energy to somebody, what would you . . . how would you describe it?*
- A-8: Heat energy is like what heat gives off, or something like that.
- Q-9: *Okay. Okay. How do you think . . . how do you think things get "hot" or get "cold"?*
- A-9: Because of the energy . . . heat energy? Or . . .?
- Q-10: *Go ahead. Don't guess. Go ahead and just tell me what you think.*
- A-10: I felt like outside, like with the weather, is when the air is fresh. Or, like, you know, 'cause like hot heat rises and cold air, well sinks . . . I don't know why. (chuckle)
- Q-11: *Okay. So you were tying it to the weather?*
- A-11: Umm Hmmm.
- Q-12: *Okay. Why did you pick the weather?*
- A-12: 'Cause mainly when you think about heat, that's what you think of. Or like temperature, I think of like in the wintertime when the temperature is cold and sometimes hot.
- Q-13: *Okay. Okay. And if I were to bring in this idea of "flow", like here it says "flows around" or "flows into" or "flows out of", do you think that heat ever flows?*
- A-13: In the air? I think like it flows like if you turn on the heat, it flows through the house. Or, however, how come you ask me? I think it flows.
- Q-14: *Okay. So, you were making. . . you were making a little sign with your finger. . . like what? You were doing this thing.*
- A-14: It circulates.
- Q-15: *This is for the tape recorder. That is why I'm doing this.*
- A-15: Oh, okay. Well, I don't know. . . just like . . .

- Q-16: *Okay. Is that like air, kinda like?*  
 A-16: *Yeah, I guess it just flows around, so. . .*  
 Q-17: *Okay. All right. Great. Well, I'm going . . . I'm going to go ahead and put these away and go on to the second question.*
- Q-18: *This next question. . . what I'd like to do is just ask you. . . Do you think that containers or wraps that keep hot objects "hot" also can keep cold objects "cold"?***  
 A-18: *Containers?*
- Q-19: *Yes, say I have a container or some kind of a material to wrap something with. . .*  
 A-19: *I think it would, uhh . . . I don't know about cold but I think it would keep it hot.*  
 Q-20: *Okay.*  
 A-20: *Because, like, say if you got like a pizza, a regular pizza, before you eat it, you got to cool it off. . . like you got a pocket pizza where it is real hot on the inside. It's like a . . . it's something like a container, you know, it's keeping the heat in, holding the heat in.*
- Q-21: *Okay. What's a pocket pizza?*  
 A-21: *You know, when you get a pocket pizza and it's got the stuff inside. . . they put on the inside, like a crust.*
- Q-22: *Oh, okay.*  
 A-22: *Although you know how you eat it. . .*  
 Q-23: *Yeah, I know, I know. Okay, what is it that keeps it hot? What is the material on the wrap?*  
 A-23: *Who?*  
 Q-24: *Just now, when we were talking about this pizza, the one you had in your head.*  
 A-24: *The dough.*  
 Q-25: *The dough?*  
 A-25: *Yeah.*  
 Q-26: *Okay. Is there anything else that they use to keep pizza hot, or is it just the dough?*  
 A-26: *I don't know, like, when they heat it up, the heat is like inside. Like it's the filling that is on the inside. It be real hot. I really don't know how it keeps it hot.*
- Q-27: *Okay. Now what about that dough, do you think that could keep things cold too?*  
 A-27: *I don't know. No, I don't think so. 'Cause like if you left it outside, it'd just. . . no, I don't think it'd keep nothing cold.*
- Q-28: *Okay, what would be . . . well, let me ask you, can you think of something else, maybe in your house, or something that you use that keeps things hot or keeps things cold?*  
 A-28: *Like I know something that keeps things cold, like the freezer.*  
 Q-29: *Okay.*  
 A-29: *You want something that's hot. . . hmmm.*  
 Q-30: *I'm thinking of something simpler, like for example, some people have cups of Styrofoam -- you've seen Styrofoam cups that people drink out of.*  
 A-30: *Umm Hmmm.*  
 Q-31: *Do you think those could keep stuff hot and keep stuff cold?*  
 A-31: *I guess. I don't know . . . a Styrofoam cup like a Tupperware thing probably could. I don't know about a Styrofoam cup, I don't know, it might.*
- Q-32: *Okay. Okay.*
- Q-33: *Well, let's talk about computers for a second, okay? Do you use computers?***  
 A-33: *No, like I use one sometimes for science lab but not really.*  
**Q-34: *Not much. . . okay. Well, I'd like for you to take a minute and think about all the different computer software that you've used and tell me, if you can tell me, what your favorite program was or is?***  
 A-34: *It would have to be like directly from a computer?*
- Q-35: *Yeah, but it could be anywhere. It could be here. It could be somewhere from your house*

- or your friend's house, or a store, or anywhere.
- A-35: Software like . . . like a disk? Something like that?
- Q-36: Yes, like what's on a disk.
- A-36: Well, at my friend's house, we play . . . at my cousin's, we play . . . *Wheel of Fortune* and *Jeopardy* and stuff like that, but I never used nothing serious, you know.
- Q-37: Okay, so I'm just going to show you this little temperature . . . this little scale and those programs -- "*Wheel of Fortune*" and "*Jeopardy*" -- that you talked about. Which one of these do you think would describe how you feel about those?
- A-37: . . . (Inaudible). . .
- Q-38: This last one? "This is the only one I've ever used".
- A-38: Umm Hmmm.
- Q-39: Okay. Do you think that these games that you play on the computer are easy to use?
- A-39: Yeah.
- Q-40: Okay. What do you think makes them easy?
- A-40: "Cause they give you instructions. . . like to press the "delete" key or "space bar" or stuff like that.
- Q-41: Okay. Do you feel like you can play them pretty well?
- A-41: Umm Hmmm.
- Q-42: How did you. . . How did you. . . Did you like them the first time you ever sat down and started using them, or did it take you a while to learn to like them?
- A-42: It took me a little while, not really to learn to like it, it took me a little while to understand how to do it because like my cousin, what she'd do is just put it in there and I didn't know how to do it, so it was just sitting there on the screen. It would just be sitting there and I didn't know whether to press it or not before then, but after I learned how to use it, it was easier, you know, it was a little bit better.
- Q-43: Okay. Do you like . . . I mean, why did you like wanting to play those two games in particular?
- A-43: Not in particular. Like I said, they were the only ones I would play. So, I guess if I played something else, it would be easy too. But oh, but at school, I, you know, I had Mr. Day and I played stuff on there like *Carmen Sandiego* and stuff like that. Some stuff is too hard. I don't understand it. So, it's like *Wheel of Fortune* is easy and, you know, *Jeopardy*, and stuff like that, it can be easy.
- Q-44: Okay, why are they easy?
- A-44: Because all you're really doing is like solving stuff whatever. Like I don't know if you've got. . . Like *Carmen Sandiego*, you gotta solve the puzzle. . . I mean crack the case and stuff like that. I don't know how to crack the case. Well, I just . . . I just don't know how to do it.
- Q-45: Umm Hmmm. Okay. Do you need to say something else?
- A-45: No.
- Q-46: Okay. Is there anything about those games that you don't like?
- A-46: I never really think about that. You know what I mean? I haven't really thought about it none like that, if I like this or not. I just play it. I don't know if I'm in love with it or I dislike it or something.
- Q-47: Hmmm. Okay. Do you think that these programs would be valuable to you in learning science?
- A-47: You mean if I do them too long? No. Like I, uhh, . . . maybe *Jeopardy*, you might find some science questions on there if I can remember but not really.
- Q-48: Okay, do you think you'd want to teach someone else how to use those two games?
- A-48: Maybe if like I knew how to do it. You mean, like, you know, if they needed help to do it, I wouldn't hesitate on helping. What do you mean, would I help them how to do it? You wouldn't . . . {indistinguishable} about it.
- Q-49: But do you think you could do it?
- A-49: What? Show them how to do it?
- Q-50: Yeah.
- A-50: Yeah.



Q-51: *Is there anything else about computers that you want to say that we haven't talked about?*

A-51: (chuckle) No, not really.

Q-52: *Okay, well, in that case, I think we're probably all done. I'll shut the tape off.*

Q-1: *We're going to go ahead and start. This will be my second interview of the day here -- the day after the freezing rain.*

A-1: Yeah, that was a little stormy.

Q-2: *Okay. What I've got first of all. . . I've got these little slips of paper and what I would like for you to do is to see if you can construct a phrase, or rather a sentence, out of these little phrases -- something that you would agree with, something that makes sense to you.* (Transcriptionist's Note: There are several loud distracting noises in the background.)

A-2: What about my time?

Q-3: *Just take your time.*

A-3: . . . (long pause) . . . I can't get nothing out of this.

Q-4: *That's all right. You can take your time. You don't have to use all of them, by the way.*

A-4: . . . (short pause) . . . I can't get nothing out of this.

Q-5: *Okay. Why don't you start with that one right there.*

A-5: Let me see if I can get something to connect to it. It's really, you know . . . that's basically what . . .

Q-6: *Okay. What would you . . . How would you define temperature?*

A-6: Oh, like heat or something, or degrees.

Q-7: *Why did you come up with that? What brought that to mind?*

A-7: Just watching the news, really.

Q-8: *Okay.*

A-8: And the temperature outside, and then . . . the house temperature.

Q-9: *So, if I were to bring this over, would you say that this word "heat" and this word "temperature" - - do you think those are the same or do you think they're different?*

A-9: Well, temperature is like talking about what the heat is.

Q-10: *Umm Hmm.*

A-10: You know, what the heat is . . . yeah, I guess . . . kind of really.

Q-11: *Okay, what if I were to bring in this other one right here -- heat energy -- and ask you to compare all three of these?*

A-11: I don't know maybe . . . I don't know about "heat energy". I don't think that it's the same as "temperature".

Q-12: *Do you think you could try and figure out what "heat energy" might mean?*

A-12: Umm . . . like maybe . . . I don't know.

Q-13: *Go ahead. Take a shot.*

A-13: Like something's blowing out heat, like a furnace or something?

Q-14: *Umm Hmm.*

A-14: Fire blowing out the heat, I guess.

Q-15: *Okay, is there something you have in mind? I mean, are you thinking of something right now when you're telling me that?*

A-15: Just catching some stuff that might throw out heat. Like a fireplace or something.

Q-16: *Okay. How do you think heat energy would get around? Like, how does it get from the fireplace out?*

A-16: Just kinda like air flows around, I guess.

Q-17: *Okay.*

A-17: It can only go so far.

Q-18: *Do you know about how far it could go?*

A-18: I don't have any idea about that.

Q-19: *Do you think you could figure out how far it could go?*

- A-19: I guess if I study sometime.
- Q-20: *Okay. All right. I'm going to go ahead and put these away now and I want to ask you a second question, okay?*
- Q-21: ***And that question is, if you have a container or wrap and if it's . . . you are able to keep something hot (something that is already hot, to keep it hot with that), do you think you could use that same container or wrap to also keep something cold?***
- A-21: Probably. Yeah.
- Q-22: *Okay. Can you . . . can you tell me why you think that might be true?*
- A-22: Well, if it could keep the hot air in, you know that we were just talking about, it could probably still keep the cold air in.
- Q-23: *Why do you think it would be able to do that?*
- A-23: Well, to keep something warm, you know, you gotta have something that could keep the heat in. You know, like if you put aluminum foil like on a coke can or something to keep it cold, I'm sure you could do it to keep something warm too.
- Q-24: *Umm. Okay. Why did you think of that? Why did you think of aluminum foil?*
- A-24: Well, like when we go on a field trip, I'll just get a can of pop and I'll wrap aluminum foil around it to keep it cold.
- Q-25: *Okay. Okay. Do you think that something else, other than aluminum foil, could work just as well?*
- A-25: Not right off the top of my head . . . like something . . . I wouldn't know how to . . . {indistinguishable . . . }
- Q-26: *Okay . . . do you think the aluminum foil could keep something hot too?*
- A-26: Not for a long time. It could keep it warm for a little bit but eventually it would get cold . . . to the room temperature degrees or whatever.
- Q-27: *Hmmm. Okay.*
- Q-28: ***Let's talk for a minute about computers. Do you use computers a lot?***
- A-28: No . . . well, my grandparents. . . I usually play with theirs a little bit.
- Q-29: *Okay. Well, think for a second about all the different programs you've used, whether they are here or at school or at your grandparents or a friend's house, or anywhere. Can you tell me what your favorite one is?*
- A-29: You're talking about like games or something?
- Q-30: *Anything. Yeah, anything at all.*
- A-30: Well, like there's this game called *Doom*.
- Q-31: *Oh yeah.*
- A-31: . . . and *Wolfenstein*. I like those two games quite a bit.
- Q-32: *Okay. I'm going to show you this little scale here and you can just pick out which one of these would best describe what you think about "Doom" or "Wolfenstein". Let's say "Doom".*
- A-32: Okay. Let's try doing *Doom*. . . (short pause) . . . Hmmm . . . this one.
- Q-33: *"By far the best I've used"? Okay. Why do you say this is your favorite? What do you like about it?*
- A-33: Well, it's just like an adventurous game. I like games like that . . . you know, all the weird little demons and stuff like that. It's pretty cool.
- Q-34: *Okay. Do you think it's an easy game to play?*
- A-34: It's about medium. It's kinda hard.
- Q-35: *Well, I'm not so much talking about how hard it is to shoot everybody and stay out of trouble. I'm thinking of just knowing how to change guns and how to move around.*
- A-35: It's all right. It's in the medium . . . you know, computing something as long as you're not in a hurry. When I'm taking my time, it's pretty easy.
- Q-36: *Did you like it the very first time you tried it or did it take a while to kind of let it grow*

- on you?*
- A-36: Well, it was . . . I didn't really like it because I didn't know how to play it but once I started learning to play it, then I started to like it.
- Q-37: *Okay. . . is there anything that you don't like about it?*
- A-37: No, not really.
- Q-38: *Okay . . . do you think this program would be of value to you in learning science?*
- A-38: No. . . (chuckle)
- Q-39: (chuckle) *How come?*
- A-39: Well, it's not really teaching me nothing . . . you know, killing things, you know, I don't really need to learn about that . . . it's just something I want to do if I got spare time.
- Q-40: Umm Hmmm. Would you want to teach someone else how to play this?
- A-40: If they asked me.
- Q-41: *If they asked you? . . . Go ahead.*
- A-41: It wouldn't be something I'd go ask em "Hey, do you want to learn how to play this game?" but if they asked me, I'd teach them.
- Q-42: *Okay. Do you think "you" could teach them?*
- A-42: Yeah, I'd just gotta get the hang of things, you know, where to put your fingers and all that on the keyboard.
- Q-43: *Okay. Is there anything else that. . . you know, all the stuff we've talked about computers . . . is there something else that we can talk about that you want to add??*
- A-43: No, that's about it.
- Q-44: *Okay. All right. Well, great. I think we're probably done then, I'm going to go ahead and shut this thing off.*
- A-44: Okay.

Q-1: *This will be my third interview, second hour, and the first thing I would like for you to do is... I've got these phrases right here and what I'd like for you to do is see if you can put a sentence together, using some of these. You can use some of them or you can use all of them or something like that. But what I'd like for you to do is try to make a sentence... and especially try to make a sentence that you agree with, or something that makes sense to you. All right, go ahead and take your time.*

A-1: ... (long pause) ...

Q-2: *If you want to try and think out loud, you can ... (short pause) ... that would be okay. Maybe I'll go ahead... Let's... Are you having trouble?*

A-2: ... Umm Hmmm ...

Q-3: *This word "temperature". What do you ... what do you think about when you see that?*

A-3: "hot" and "cold". . . you know, about how hot or how cold it is.

Q-4: *Okay. What about this word here --"heat"? What does that word talk to you about?*

A-4: "hot" and "heat in something".

Q-5: *Okay, do you think these two things are the same or do you think they're different?*

A-5: The same.

Q-6: *Okay... how do you... how do you... I'm sorry, what did you say?*

A-6: I think tht they're probably... I think they're the same.

Q-7: *Okay. You can speak up a little louder too. That way, I don't have to listen so hard afterwards. How do you think they're the same?*

A-7: ... uhh... (long pause) ... the temperature in your house.

Q-8: *Okay.*

A-8: ... uhh...

Q-9: *Do you have a picture in your head of some sort right now?*

A-9: Umm Hmmm ...

Q-10: *Okay. What about this word here --"heat energy". Does that mean anything to you?*

A-10: Umm Umm(no).

Q-11: *Okay. Okay. Great. You know what I'm going to do. I'm going to go ahead and put these away. I'm going to move on to a second question.*

Q-12: *The next question I want to ask you is. Let's say you have this material, something you can wrap something with, okay? Do you think this material could be used to keep hot objects hot and to keep cold objects cold? Or could this just be used for one or the other.*

A-12: It could only be used for one or the other.

Q-13: *Okay. Why would you say that?*

A-13: You could use something to keep it cold, or you could use it to keep something hot, you know. You could wrap something and put it in the freezer to keep it cool or cold. Also, you could wrap something, you know, to keep it... that heat inside.

Q-14: *Okay. Let's pick a "something". Let's pick "aluminum foil". Could you use that to keep something hot?*

A-14: Ummhmm. You can keep the heat inside when you're cooking.

Q-15: *Okay. How does it keep something hot?*

A-15: Well, I don't really know.

Q-16: *Do you think it could be used to keep something cold?*

A-16: Might be but I don't know for sure.

Q-17: *Okay. Can you think of something else that people use, maybe, to keep things hot or keep things cold?*

A-17: . . . (long pause) . . . the Ziploc bags. You can store things in them and keep them cool  
Q-18: *Okay. Okay.*

**Q-19: *Let's talk for a minute about computers? Do you use computers any?***

A-19: No.

Q-20: *No? I was wondering . . . have you ever used a computer before?*

A-20: Yeah.

Q-21: *Think about the different programs you used, or the different disks you've used and can you tell me what your favorite one was?*

A-21: I don't know . . . (short pause) . . . let's see . . . the one that we did in Mr. Caney's (spelling?) class . . . about the weather.

Q-22: *Okay. What did you like about it?*

A-22: It showed you the temperatures.

Q-23: *I'm going to switch the tape right now . . . (CHANGE TO TAPE 4) . . . Okay, let's pick it up again.*

A-23: Well, in Mr. Caney's (spelling?) class, it can show temperatures and the way that the storms and this stuff was going on.

Q-24: *Okay. Did you think it was easy to use . . . easy for you to use?*

A-24: No . . . yeah, it was pretty easy.

Q-25: *Why do you think it was easy?*

A-25: Well, you could use the mouse and . . . just move it and . . . you could take it and just look around and see things.

Q-26: *Okay. Was there anything about using that software that you didn't like?*

A-26: Well . . . being patient.

Q-27: *Why did you have to be patient?*

A-27: . . . (short pause) . . . I forgot what it was called . . . (indistinguishable) . . .

Q-28: *"Are you a mother"?* "Blue Sky's"?

A-28: Yeah. . . these? *UM - Weather*

Q-29: *Oh, the modem?*

A-29: Yeah, how to select the bars and the keys. . .

Q-30: *Oh, okay.*

A-30: . . . how to find the things . . . how to find the temperatures and then you had to wait for a while.

Q-31: *Okay. Do you think that this program was valuable to you in learning science?*

A-31: Yeah, it could be.

Q-32: *Okay. Why do you say that?*

A-32: Well, like it shows you which way the weather and that stuff comes from and how you can see how the temperatures are . . . you can see how the climate is and you can learn which ways, I don't know, how hot and cold forms and stuff like that.

Q-33: *Okay. Do you think you'd want to teach someone else how to use this?*

A-33: Umm . . . Yeah.

Q-34: *Why?*

A-34: I think it would pretty fun for a person who hasn't done it.

Q-35: *Okay. Do you think you could teach it?*

A-35: If I knew more about it, I could teach it.

Q-36: *Okay. (Fire alarm sounds in the background) Another fire alarm, huh? (chuckle) Okay. So if you knew more about it, you think you could probably do it. Okay. Is there anything else about computers you want to mention that we haven't talked about?*

A-36: . . . (short pause) . . . No.

Q-37: *Okay. I think we're done. I'm going to go ahead and shut this off now, okay?*

- Q-1: *Now that I've started the tape, I'm going to get these things done. These little scraps of paper... what I'd like for you to do is form a sentence out of this that you would agree with, okay? So, you don't have to use all of the words. You can just use some of them if you want. You can use all of them if you want. Just try and see if you can make a sentence out of this that you agree with or something you think is true, or something that you think is a fact. . . . (long pause) . . . okay. I can give you copies, if you want, of any of these, if you want to use a copy of them.*
- A-1: . . . yeah, that one . . . (short pause) . . . and "temperature".
- Q-2: *That's quite a . . . quite a sentence . . . could you read it for me?*
- A-2: Heat stays in higher temperature and cold stays in lower temperature.
- Q-3: *Okay. Great. Now, could you tell me what it is about that you like or what you agree with? Why do you think that's true?*
- A-3: Because heat makes the temperature go higher and cold makes the temperature go lower.
- Q-4: *Okay. What would you call this? How would you define this word "heat"?*
- A-4: "hot", "warm". . . .
- Q-5: *Okay. Let's say I didn't really know . . . like I was somebody from another country or something, and I didn't really know what "hot" or "warm" meant. How would you describe heat?*
- A-5: . . . (long pause) . . . .
- Q-6: *Let's look at this word here - "temperature". Could you tell me what you think this word means?*
- A-6: Like how hot it is or how cold it is.
- Q-7: *Okay. Now these two words right here -- heat and temperature -- do you see those as being the same or different?*
- A-7: They're kinda the same.
- Q-8: *How would they be kinda the same?*
- A-8: Because heat is a temperature.
- Q-9: *Okay. Now why did you say that heat stays in higher temperature?*
- A-9: Because that's exactly what they taught us.
- Q-10: *Okay. Why does heat stay in higher temperature?*
- A-10: Well, 'cause the hotter it is the higher temperature it is.
- Q-11: *Okay. Would I be able to say the same thing about this part -- cold stays in lower temperature?*
- A-11: Umm Hmmm.
- Q-12: *Okay. What if I were to bring this word in . . . this word over here . . . "heat energy"? What would this mean to you?*
- A-12: Like, heat from the sun.
- Q-13: *Okay. Why did you think of that?*
- A-13: I don't know, it was just off the top of my head.
- Q-14: *Do you see "heat energy" and "heat" being the same or being different?*
- A-14: . . . (short pause) . . . The same.
- Q-15: *Okay. What about "heat energy" and "temperature"?*
- A-15: Different.
- Q-16: *Okay. How would they be different?*
- A-16: Because "temperature" is a totally different thing from "heat". . . from "heat energy".
- Q-17: *How is it different?*
- A-17: Because "temperature" is something that you measure with and I don't really know what

- "heat energy" is.
- Q-18: *Okay. Temperature is something that you measure with. . . that you measure with, you said? What do you measure with it?*
- A-18: How hot or cold it is.
- Q-19: *Okay. . . (short pause) . . . When you say here that "it stays in", what do you mean by "it stays in"?*
- A-19: That it's always there.
- Q-20: *Okay. "That it's always there" . . . Why would it always be there?*
- A-20: Because it says it stays in. (chuckle)
- Q-21: *Okay. Great. I'm going to go ahead and put these away and go on to another question. Does that sound okay? I'd better put my "extras" away first.*
- Q-22: *Here is the next question. I'm going to name a material and I'd like for you to tell me if you would use it for keeping something hot, if you would use it for keeping something cold or if you would not use it for either one. Okay? Or I guess I should also say that you could use it for both. So, I'll name the material. You tell me if you could use it to keep something hot, keep something cold, for both, or neither. Okay? The first material is aluminum foil.*
- A-22: Hot.
- Q-23: *Okay. Why would you say that?*
- A-23: Because it keeps like . . . uhh . . . keeps it from ruining . . . well, hot or cold.
- Q-24: *Okay, now, go ahead.*
- A-24: It just keeps it from ruining.
- Q-25: *Keeps it from ruining? What does that mean, really?*
- A-25: Spoil . . . ing.
- Q-26: *Okay. Do you have a picture in your head? Or something you can think of to . . . that makes you believe this is true?*
- A-26: It's like when you wrap something up when you're not using it.
- Q-27: *What sorts of things do you wrap up?*
- A-27: Like food or something.
- Q-28: *Okay. Okay. here's another material -- wool.*
- A-28: To keep something warm . . . or hot.
- Q-29: *Can you use it to keep something cold?*
- A-29: . . . (inaudible) . . .
- Q-30: *No? Okay. Why would it be good for keeping something hot?*
- A-30: 'Cause they make clothes out of it . . . clothing are to be . . . for warmth.
- Q-31: *Hmmm. Okay. How do you know this? Do you have something that is wool?*
- A-31: . . . (inaudible) . . .
- Q-32: *Okay. What about Styrofoam?*
- A-32: Neither.
- Q-33: *Neither. Why do you say neither?*
- A-33: I can't think of anything that would make it hot or cold.
- Q-34: *Okay. Now, what is it about, going back a little bit, what is it about aluminum foil and wool, both, that would keep something warm?*
- A-34: What?
- Q-35: *Is there something that's the same about aluminum foil and wool that . . . 'cause they both keep stuff warm?*
- A-35: No.
- Q-36: *No? Okay. Is there something that aluminum foil and wool have that Styrofoam doesn't have? And that's why Styrofoam can't keep something warm?*
- A-36: . . . (tape distortion) . . .
- Q-37: *So, why do you think aluminum foil and wool can keep something warm and Styrofoam can't?*
- A-37: Sometimes anything can try to be kept warm or cool in Styrofoam.



Q-38: *Okay. Okay. That sounds good.*

Q-39: *Let's talk about computers for a second. Do you use computers a lot?*

A-39: No.

Q-40: *Have you ever used a computer before?*

A-40: Yeah.

Q-41: *Okay. I'd like for you to think about all the different computer programs that you've used and tell me which one you'd say was your favorite.*

A-41: What . . . like games?

Q-42: *It could be anything. It could be a game. It could be something you did here in school -- a game you did in school. It could be something you did to learn with, or anything.*

A-42: *The Writing Center.*

Q-43: *"The Writing Center". Okay. Now, why . . . Now, I'm going to show you this list and you could pick out which one of these describe what you think about "The Writing Center" . . . (short pause) . . . The second one? Could you read that one?*

A-43: I picked this as the best, but I did think about other ones.

Q-44: *Okay, now what is it about "The Writing Center" that makes it your favorite?*

A-44: 'Cause you can do a lot of stuff on it. You can write letters. You can do your homework.

Q-45: *Okay. Umm. Do you think it's hard to use or do you think it's easy to use?*

A-45: It's easy.

Q-46: *Why do you think it's easy to use?*

A-46: "Cause all I have to do is go through a few files and it's just there.

Q-47: *Okay. Now, did you like it from the very first time you tried it or did it take a while to grow on you?*

A-47: I liked it all the while.

Q-48: *Okay. What did you like about it? I asked you that. I sort of asked you that, but I'm thinking about using the program itself, not what you are using it for -- but just about using the program itself. What do you like about it?*

A-48: Well, it's handy.

Q-49: *Okay. Uhh, I know some people have said that . . . you know, they like, sometimes they like it because they can do everything with a mouse. Some people like it because they can do things like typing. I don't know. Some people like seeing lots of pictures and stuff.*

A-49: I just like typing on it.

Q-50: *Okay. Okay. Is there anything about "The Writing Center" that you don't like?*

A-50: No.

Q-51: *Okay. Do you think this program would be of value to you in learning science?*

A-51: I don't know.

Q-52: *Can you try and guess and see if maybe it would? Think of a way maybe if it could help you learn or be of value or think how it absolutely wouldn't be of value.*

A-52: I can't think of one.

Q-53: *Okay. Do you think you'd want to teach someone else how to use this program?*

A-53: Not really.

Q-54: *No? Do you think you could teach "period"? I mean if someone wanted to learn, do you think you could teach them?*

A-54: Yeah.

Q-55: *Yeah? Why do you say that?*

A-55: 'Cause its easy to do and I like know how to do it.

Q-56: *Okay. Now, of all the stuff we've talked so far about computers, is there anything you want to add to all that?*

A-56: No.

Q-57: *Okay. Well, I think we're probably all done. I'm going to go ahead and shut this off.*

- Q-1: *... Now, in case I have to flip it over, while we're talking, I'll just tell you when I hear it about ready to go and what we'll do is, we'll stop and I'll flip it and then we'll pick it up again. Okay? Would you believe that this is already my fifth interview today? I've got some words here on these papers, and what I'd like for you to do is, I'd like for you to try and make a sentence out of this that you would agree with, or that you would consider to be true, or that you would consider to be a fact. . . . (long pause) . . . You can think out loud if you want. Or is it . . . ? . . . (long pause) . . . Okay, can you go ahead and just read that?*
- A-1: Cold energy flows around cold temperature.
- Q-2: *Okay. Can you tell me what you think this is? Cold energy?*
- A-2: Energy that's cold, you know . . . (long pause) . . .
- Q-3: *Is there something you can picture in your head that would describe it? A machine or something like that? Or something that you see out in nature?*
- A-3: . . . {indistinguishable} . . . (long pause) . . .
- Q-4: *I'll tell you what. Let's go over here to this word over here -- "temperature". Okay? Can you tell me what you think this means?*
- A-4: *Hmmm . . . cold or hot degrees . . . like the temperature of the weather would be hotter and colder and . . .*
- Q-5: *Okay. Now, what if I were to pull this word over -- "heat? What do you . . . what would this word mean to you?*
- A-5 : This?
- Q-6: *Okay, go ahead.*
- A-6: I don't know.
- Q-7: *What if I pulled this word over -- heat energy?*
- A-7: . . . (long pause) . . . hot temperature.
- Q-8: *Okay. Now, do you think that "temperature" and "heat energy" . . . do you think these are the same or do you think they're different?*
- A-8: . . . (long pause) . . . it would be the same if you . . . you know . . . if the temperature is hot.
- Q-9: *Okay. So, what about this one?*
- A-9: If the temperature is cold?
- Q-10: *Okay. Okay. So, you're saying "temperature" and "heat energy" would be the same if the temperature was hot or high, and "temperature" and "cold energy" would be the same if the temperature was low.*
- A-10: Umm Hmmm.
- Q-11: *Okay. Good. I'm going to pull these out of the way now and I'm going to ask you a second question.*
- Q-12: *What I'm going to do is . . . I'm going to name a material and I'd like for you to tell me if you would use that material for keeping something hot, for keeping something cold, for doing both or for doing neither. Okay? First material is aluminum foil.*
- A-12: Cold temperature.
- Q-13: *Okay. Why would you say that?*
- A-13: Because it's a hot temperature, it could melt.
- Q-14: *Okay. Is there something . . . something that you have in your head that made you answer aluminum foil? Are you picturing something? Or can you right now picture something?*
- A-14: . . . (long pause) . . . Well, it could mean both actually. . . it could mean "hot" or "cold temperature.

- Q-15: *Okay. Why do you say that?*  
A-15: . . . (long pause) . . .  
Q-16: *Can't think of something right now? Okay. Let's go to another material. How about wool?*  
A-16: *It could be in both temperatures.*  
Q-17: *Why would you use wool for keeping something cold?*  
A-17: . . . (long pause) . . . I don't know.  
Q-18: *Why would you use it for keeping something warm?*  
A-18: . . . (long pause) . . . I can't think right now.  
Q-19: *Okay. I'll name another material -- Styrofoam.*  
A-19: . . . (long pause) . . . neither . . .  
Q-20: *Does that mean neither or you can't think of anything or. . .*  
A-20: *I just can't think of anything.*  
Q-21: *Okay.*
- Q-22: *Let's go ahead and talk about computers for a minute, okay? Do you use computers a lot?***  
A-22: *Umm Hmmm.*
- Q-23: *Do you? Okay. Think about all the different computer software that you've used and tell me what you would call your favorite program?*  
A-23: . . . (short pause) . . . you mean like at school or somewhere?  
Q-24: *Anywhere. At school, at home, or a friend's house, or anywhere.*  
A-24: *Well, we use a lot of disks. There's a lot of them around.*  
Q-25: *Okay. So, you're saying that you couldn't pick any one thing. There's a lot that you like?*  
A-25: *Umm Hmmm.*  
Q-26: *Okay. Can you think of just one example of one? Just pick one that you like. It doesn't have to be your favorite but just pick one that you like.*  
A-26: . . . (short pause) . . . I can't think of one.  
Q-27: *Can't think of one? Okay. Do you find using the computer to be pretty easy or pretty hard?*  
A-27: *Pretty easy.*  
Q-28: *Pretty easy. Why do you think it's easy?*  
A-28: *'Cause I ended up knowing how to do it, I guess.*  
Q-29: *Okay. Did somebody teach you or did you learn by yourself mainly?*  
A-29: *Oh, I had somebody teach me.*  
Q-30: *You did? Okay. Do you think you can teach other people how to use the computer?*  
A-30: *I probably could. I think I can.*  
Q-31: *Do you think people are interested in using the computer?*  
A-31: *They might.*  
Q-32: *Okay, do you think that the computer is valuable for learning science?*  
A-32: *Yeah.*  
Q-33: *Why would you think that?*  
A-33: . . . (long pause) . . . I don't know. . . (long pause)  
Q-34: *Okay. Can't think of a good reason? Okay. Of all the stuff I've asked you about computers, is there something we haven't talked about that you want to add?*  
A-34: *No.*  
Q-35: *No? Okay. Well, I think I'm going ahead and shut this off then. All right?*

- Q-1: *This is Interview 6, second day . . . and what I'm going to do is, I'm going to put out some words right here and what I'd like for you to do is to see if you can make a sentence out of these words that you would agree with or that would make sense to you, or something that you think is a fact.*
- A-1: Make a sentence out of each one?
- Q-2: *No. Make one sentence, using these as the parts, kinda like a little puzzle thing.*
- A-2: Oh, so make a whole sentence with all these words?
- Q-3: *Oh, you don't have to use all of them. You can just use some of them.*
- A-3: . . . (Sounds like a sigh) . . .
- Q-4: *Okay. You could use three or four, five, six or seven, I think.*
- A-4: Oh. That's pretty hard.
- Q-5: *Yeah but I think you can do it.*
- A-5: Umm . . . umm. . . I don't know what to do?
- Q-6: *Go ahead and try it. I mean, we've got time. Go ahead and take your time.*
- A-6: Umm Hmmm . . . (long pause) . . . Umm Hmmm . . . You need to like help me a little bit here.
- Q-7: *Okay. Tell you what. Tell me what you think of when you see that word right there?*
- A-7: Hot and cold.
- Q-8: Okay. Why do you . . . . ?
- A-8: Heat and cold.
- Q-9: *Why does this make you think of hot and cold?*
- A-9: 'Cause I just know what it is.
- Q-10: *Okay. What if I didn't have a clue what hot and cold was, how could you explain that to me?*
- A-10: Hot is like . . hot . . You just know. It's a natural habitat.
- Q-11: *Okay. What about this word right here -- "heat"?*
- A-11: Umm . . . huh . . . it's like something that comes from the sun.
- Q-12: *Okay.*
- A-12: Or electric heater.
- Q-13: *Okay. So you were thinking of the sun and you were thinking of an electric heater?*
- A-13: Yeah.
- Q-14: *Now, do you see these two "heat" and "temperature" as being the same or different?*
- A-14: Different.
- Q-15: Okay.
- A-15: No, it has to be the same, in a way.
- Q-16: *Okay. How are they the same?*
- A-16: 'Cause it has to do with temperature.
- Q-17: *What does?*
- A-17: Heat.
- Q-18: *Okay. Now how are they different?*
- A-18: Oh. It ain't a temperature. It ain't like so and so how much. It's just part that's high or low. It's the higher part.
- Q-19: *Okay. I see what you're saying? What about this word here -- "heat energy"?*
- A-19: I don't know.
- Q-20: *Have you ever seen that word . . . or that phrase before?*
- A-20: Nope.
- Q-21: *No. Okay. I was wondering. How does heat . . . do you think heat travels from thing to thing or from place to place?*

- A-21: Well, yeah.  
 Q-22: How does it travel?  
 A-22: Umm . . . by itself. (chuckle)  
 Q-23: By itself.  
 A-23: . . . (chuckle) . . . it just travels. . .  
 Q-24: *Well, you've got the sun where the sun is and we're here and we feel the heat from the sun.*  
 A-24: Umm Hmmm.  
 Q-25: *So, how does that heat get from the sun to us?*  
 A-25: How do we feel it?  
 Q-26: *Yeah.*  
 A-26: It's like a direct ray. . . ray, you know?  
 Q-27: *Okay.*  
 A-27: It's right at us.  
 Q-28: *What about an electric heater? You talked about an electric heater. . .*  
 A-28: It . . . (CHANGE TO SIDE B OF TAPE 4) . . . It produces heat from the other heat like the air in the room and brings it in and heats it and it flows out the other end.  
 Q-29: *Okay. How does the heat get to me if I'm in the other room?*  
 A-29: It circulates.  
 Q-30: Okay . . .  
 A-30: Around the room.  
 Q-31: *Okay. Great. Well, I'm going to go ahead and put these away and the next thing I want to do is . . .*
- Q-32: *I'm going to ask you . . . I'm going to name some materials and I'd like for you to tell me if I could use that material for keeping something hot or for keeping something cold, or for doing both, or for doing neither. Okay?***
- A-32: Umm Hmmm.  
**Q-33: *The first material is aluminum foil.***  
 A-33: It would keep it from burn . . . something from burning.
- Q-34: *Okay. Now, how does it work to do that?*  
 A-34: I don't know . . . It's in the oven . . . I just see it in the oven.  
 Q-35: *Okay. You're thinking of like some food?*  
 A-35: *Yep.*  
 Q-36: *And, can you tell me what . . .*  
 A-36: It can keep it. If you take a pop and wrap it around it, it will keep it colder than it would if you didn't have it around it.
- 
- Q-37: *Okay. So, you're saying . . .*  
 A-37: And it can keep something hot too.  
 Q-38: *So, you're saying it can do both.*  
 A-38: *Yeah.*  
 Q-39: *How does it keep stuff cold?*  
 A-39: It don't let the coldness out. It traps it in.  
 Q-40: *Okay, and how would it keep something hot?*  
 A-40: The same thing, just the other way around.  
 Q-41: *Okay. How about wool?*  
 A-41: Wool. It can keep you warm 'cause it's a certain fabric that you can put it on and it keeps something warm.  
 Q-42: *Okay. How does it keep . . . how does it keep you warm?*  
 A-42: It's . . . it's just so thick that you can't get cold.  
 Q-43: *Okay. Umm, now I'm curious. Could you keep something cold with wool?*  
 A-43: Nope. I don't think so.  
 Q-44: *Okay.*  
 A-44: I think it'd make it hot.

- Q-45: *Okay. Next material -- "Styrofoam".*  
A-45: It can do neither. It's made for packaging.  
Q-46: *Okay. Umm, how come it wouldn't be any good for doing either one?*  
A-46: It's just not that type of material.  
Q-47: *Okay. So, there's something in the Styrofoam itself that just doesn't let it keep . . .*  
A-47: It ain't flexible.  
Q-48: *Okay.*
- Q-49: *Okay, let's go ahead and talk about computers. Do you use computers a lot?***  
A-49: Yeah. I got one.  
**Q-50: *You do? Okay. Cool.***  
A-50: An IBM 46 Super Bissau IBM Compatible.  
**Q-51: *Hmmm. Sounds like quite a system there.***  
A-51: With sound blaster.  
**Q-52: *With sound blaster? I want you to think about all the different software that you use at home, here at school, maybe at a friend's house, whatever, and tell me what your favorite program is.***  
A-52: *Doom.*  
**Q-53: *"Doom". Another "Doom" fan. Umm, I'm going to show you a scale and I'd like for you to pick out which one of these would best describe how you feel about "Doom".***  
A-53: . . . (Sounds like a sight) . . . That one.
- Q-54: *Could you read that?*  
A-54: By far the best I've used.  
Q-55: *Now, why would you say that "Doom" is by far the best you've used?*  
A-55: Just the graphics and the point of the game.  
Q-56: *Okay. What is it about the graphics that you like?*  
A-56: It's that it's kinda real.  
Q-57: *Okay. And the point of the game?*  
A-57: You like . . . you gotta try, like . . . kill everything to get out.  
Q-58: *Umm Hmmm.*  
A-58: And . . . hit all the keys and what do they mean . . . you know.  
Q-59: *Right. All right. Did you like "Doom" the very first . . . from the very first time you tried it or did it have to grow on you?*  
A-59: I liked it the first time.  
Q-60: *Did you? Okay.*  
A-60: Yeah.
- Q-61: *Do you consider "Doom" to be easy or hard?*  
A-61: It matter which . . . {indistinguishable} . . . you're on.  
Q-62: *I'm not so much talking about trying to kill people but more how to use it, like knowing when to change weapons or how to change weapons . . .*  
A-62: You gotta like study it to really know it.  
Q-63: *Okay. How do you go about studying it?*  
A-63: Go to F-1 and read what it says.  
Q-64: *Okay. So, you're saying there's some kind of a "help thing" that's built into the program?*  
A-64: . . . {inaudible} . . .  
Q-65: *Okay. Is there anything you don't like about "Doom"?*  
A-65: I can't get the . . . two of the last guns.  
Q-66: *You can't get the two last guns. Okay. Do you think this program would be of value to you in learning science?*  
A-66: No. (chuckle)  
Q-67: *Why not?*  
A-67: (chuckle) . . . 'Cause it's not for that kind of thing.

Q-68: *Okay.*  
A-68: *It's for home use.*  
Q-69: *Okay. Would you want to teach someone else how to use the program?*  
A-69: *I already did.*  
Q-70: *Who?*  
A-70: *My friend.*  
Q-71: *Oh, really? Did they learn?*  
A-71: *Yep. In two times.*  
Q-72: *In two times. Good, so "you" were able to teach them. You were able to teach?*  
A-72: *Yep. I got all the codes . . . {indistinguishable} . . . and went through the walls.*  
Q-73: *Oh, yeah, all that stuff. Now of all the stuff I've asked you about computers, is there something you'd want to add to all of that?*  
A-73: *. . . (short pause) . . . umm . . . no.*  
Q-74: *No? Okay. Well, I think we're all done. I'm going to go ahead and shut this off.*

Q-1: *This is already my seventh interview of the day. Okay, the first thing I'm going to do is, I'm going to put out these little words here and what I'd like for you to do is try and make a sentence out of these. You don't have to use all of them. You could just use some of them if you want but try and make a sentence that makes sense to you or something you would agree with or something you would call a fact . . . (long pause). . . (loud youthful noises are heard in the background) . . . Fun going all around here? Let me ask you about this word here -- temperature. What does that mean to you?*

A-1: Heat or coldness or something.

Q-2: *Okay. Is there something you have in mind when you say that? Are you picturing something?*

A-2: Well. I saw a picture of the sun most of the time.

Q-3: *The sun? Okay, why did you pick the sun?*

A-3: I don't know, just seeing it.

Q-4: *Okay. What about this word over here -- heat?*

A-4: For some reason, I always picture a stove.

Q-5: *What is it about the stove that . . . ?*

A-5: I don't know, just a fire.

Q-6: *Okay. You have a gas stove?*

A-6: Yeah.

Q-7: *Which . . . do you see these two words as being the same or different?*

A-7: . . . (short pause) . . . heat is a temperature so they're kinda the same.

Q-8: *Okay. Let me put this one in here -- "heat energy". What does that mean to you?*

A-8: Just . . . I see it as the same as heat.

Q-9: *Okay. Do you see "heat energy" as the same as "temperature"?*

A-9: Yeah.

Q-10: *Okay. So you'd say all three of these are kinda the same.*

A-10: Yeah.

Q-11: *Okay. Let me ask you one more thing. How . . . Do you think that heat travels or moves from one place to another?*

A-11: I guess it just travels around and then . . .

Q-12: *Go ahead.*

A-12: I don't really know.

Q-13: *Okay. Let's see, I think I'm going to go ahead and put these up now and I'll ask you another question.*

Q-14: *Now, for this next question, I'm going to name a material and what I'd like for you to do is to tell me (whoops) . . . tell me if you think that material could be good for keeping something hot, for keeping something cold, for doing both, or neither one. Okay? The first material is aluminum foil.*

A-14: Keeping something hot.

Q-15: *Okay, why would you say that?*

A-15: Oh, I don't know. It's made of aluminum so it kinda traps the heat inside of it. It would probably keep something cold too though.

Q-16: *Okay, why would you say that?*

A-16: Just like heat, it would trap the coldness inside of it. Usually metal things get really cold.

Q-17: *Okay, what about wool?*



- A-17: Wool?
- Q-18: *Umm Hmmm.*
- A-18: Probably keep heat in since people make sweaters out of wool, so . . .
- Q-19: *Do you think wool would be good for keeping something cold?*
- A-19: No, probably not.
- Q-20: *No? Okay. Why not?*
- A-20: 'Cause it's like this great big burly material that's made for keeping stuff warm.
- Q-21: *Okay. What about Styrofoam?*
- A-21: I don't think it'd really do anything?
- Q-22: *No? Why not?*
- A-22: I don't think it's related to . . . not really . . . you know, to anything that'd keep anything warm or cold.
- Q-23: *Okay. That sounds good.*
- Q-24: *I think we'll talk about computers now. Do you use computers a lot?***
- A-24: Whenever I'm in school.
- Q-25: *Okay, so you use them here? I want you to think about all the different software that you've used and tell me which one you'd pick as your favorite.***
- A-25: I like the games.
- Q-26: *That's okay. It could be anything.*
- A-26: Like *Wolfenstein* . . . {indistinguishable} . . .
- Q-27: *Okay. If I were to show you this scale here. Could you tell me which one of those would describe how you feel about "Wolfenstein"?*
- A-27: This one.
- Q-28: *Could you read that one?*
- A-28: I picked this as the best but I did think about other ones.
- Q-29: *So, why would you say that "Wolfenstein" is your favorite?*
- A-29: I just like playing it. I haven't played it a whole lot but just over at my friend's house, you know, . . . it's just fun.
- Q-30: *Umm Hmmm. Is there something about it . . . is there something that you do with it that you really like?*
- A-30: No. It's just fun.
- Q-31: *Okay. Okay. I was wondering, uhh, did you like it the very first time you played it or did it take a while to grow on you?*
- A-31: I liked it the very first time I played it.
- Q-32: *Okay.*
- A-32: The first time I played it was like in Sears but I like stuff like that.
- Q-33: *Okay. Do you consider it to be easy or hard to use?*
- A-33: It's easy. You just press the little button every once in a while.
- Q-34: *Okay. Is there anything that you don't like about it?*
- A-34: No. No.
- Q-35: *No? Okay. Do you think this program would be of value to you in learning science?*
- A-35: Probably not.
- Q-36: *Why not?*
- A-36: Well, like it has really nothing to do with science.
- Q-37: *Okay. Do you think you'd want to teach someone else how to use this program?*
- A-37: Yeah.
- Q-38: *Okay. Do you think "you" could teach them?*
- A-38: Yeah.
- Q-39: *Why?*
- A-39: Well, it's not that hard to learn. My friend taught me how to use it. Like he taught me in a couple of days just what to do with it, so it's not really that hard to learn.
- Q-40: *Hmmm. Okay. Now, of all the stuff I've asked you about computers so far, is there*

*something we haven't talked about that you want to say about it?*

A-40: No, not really.

Q-41: *No? Okay. Well, I think we're all done. I'm going to go ahead and shut the tape off now.*

- Q-1: *... All eighth graders, all in Mr. Caney's science class and you're Number 8. It's been a busy day for me, that's for sure.*
- A-1: All girls or boys too?
- Q-2: *Both. It's a mixed bag of just about everything. Okay, what I'm going to do is I'm going to lay out some words here in front of you and what I'd like for you to do is just try and pick out some of these. You can use some of them. You can use all of them, however many you want. Try and make a complete sentence that you would agree with or that you would say is a fact or that you would say is true.*
- A-2: Okay . . . (long pause) . . . okay, I've got the sentence.
- Q-3: *Okay. Let's move these other ones out of the way. Can you go ahead and read that?*
- A-3: Objects at a higher temperature flows around.
- Q-4: *Okay. Now, can you tell me what it is about that sentence that you think is true?*
- A-4: Like the hot air like rises.
- Q-5: *Okay. Okay. What do you think this word -- "temperature" . . . what would you say that means?*
- A-5: Like . . . like the degree of what that heat is . . . like if it's cold or hot.
- Q-6: *Okay. Why did you choose this "flows"? What is this word -- flows around?*
- A-6: It like moves around in the air. It doesn't just stay inside.
- Q-7: *And we're talking about . . . when you say it?*
- A-7: Heat . . . the heat.
- Q-8: *Heat. Okay. Now if I bring out this word "heat" over here next to "temperature", what does that word "heat" mean to you?*
- A-8: Just . . . it means like . . . the same thing as . . . it can mean "hot" or it can mean just the like degree of heat, if it's like hot or cold.
- Q-9: *Okay. Do you see "heat" and "temperature" as being the same or different?*
- A-9: They're kinda . . . and it's like . . . if you look at it one way they're the same. If you look at it a different way, then they're different.
- Q-10: *Okay. How are they the same?*
- A-10: They're the same 'cause like the temperature is like the degree and like "heat" can be like a degree too . . . it's just like . . . like at my house . . . like when you turn up the heat, it's like you turn up the temperature. It's kinda like the same thing.
- Q-11: *Umm Hmmm.*
- A-11: It's almost like kinda the same thing.
- Q-12: *Okay. Now, how would you say they're different?*
- A-12: They're different 'cause like if . . . it's like, well, "temperature" doesn't mean hot or cold, it just means . . . you know . . . like what the degree is and "heat" can be meaning "hot".
- Q-13: *Okay. Okay. Now, what if I take this term right here -- "heat energy". What does that mean to you?*
- A-13: Just like . . . like the energy from like heat like . . . like the sun gives off heat energy for like plants and stuff, I guess.
- Q-14: *Okay. Do you see a difference between what the sun gives off and what comes out of your heater at your house?*
- A-14: Yeah 'cause the sun is like . . . It's like solar power and the heat is like from electricity.
- Q-15: *Okay. Okay. Would you say that "heat energy" and "temperature" . . . or "heat energy" and "heat" are the same . . . or are they different?*
- A-15: They're like . . . I guess they're kinda different 'cause like "heat energy" means like the energy from the heat might . . . it does something, like, you know, gives off energy and just

- ... I guess ... I don't know.
- Q-16: *Okay. All right. Sounds good. I'm going to go ahead and put all of these away now.*
- Q-17: *The second thing I want to do is to ask you this question and I'd just like for you to tell me ... uhh, do you think that a container or wrap that helps keep hot objects hot also helps keep cold objects cold?*
- A-17: Probably. Yeah.
- Q-18: *Now why would you say "probably"?*
- A-18: Because like if it's designed to make it ... to keep it hot, then it's probably going to keep it cold if the thing is cold already.
- Q-19: *Okay. Is there something in your head that helps you figure this out? Can you think of an example?*
- A-19: Something in my head.
- Q-20: *Yeah.*
- A-20: My brain (chuckle).
- Q-21: *Your brain. I mean, a picture in your head, you know.*
- A-21: I just ... it's like ... Hmmm ... the question you just asked me?
- Q-22: *Umm Hmmm.*
- A-22: Like when my mom goes to the grocery store, she just like gets freezer wraps or whatever or stuff to keep it in the fridge and sometimes like if you keep ... like if you put it in a little plastic bag and it's already hot, it stays hot for awhile and if it's cold, it stays cold for awhile.
- Q-23: *Okay. Now, why do you think it does that?*
- A-23: Because there's like ... 'cause there's like no air in it and it can't really change that much unless like if it sits in the fridge for a long time.
- Q-24: *Okay. And then what happens?*
- A-24: Like if it's hot, it'll get cold and if it's cold, it'll get colder.
- Q-25: *Okay. Now what is it about the bag that you think makes that happen? Or is it anything about the bag?*
- A-25: It's like ... if it's like the Ziploc kind, there 's like no air that gets into it so that it can't really change that much.
- Q-26: *Okay, so you're saying the air is what makes the difference?*
- A-26: It makes part of the difference. Like if the air's cold, then it'd'll probably stay colder. If the air is warm then it'd'll probably stay warmer.
- Q-27: *So you say air makes part of the difference. Is there something else that also makes the rest of the difference?*
- A-27: Well, uhh ... I don't know. Guess not.
- Q-28: *Okay. Okay. That's good.*
- Q-29: *Let's talk about computers. I'd like ... do you use computers a lot?*
- A-29: I've got one at home.
- Q-30: *Do you? Okay. Good. I'd like for you to think about all the computer software that you've used and tell me which one you would think of as your favorite?*
- A-30: You mean which type of computer?
- Q-31: *No, No. Which software? Which program?*
- A-31: Probably drawing, on the Macintosh.
- Q-32: *Okay. Is there a program name like ... ?*
- A-32: *Kid Pix.*
- Q-33: *"Kid Pix". Oh, okay. I'm going to show you a scale here ... oops ... I'm going to show you a scale here and I was wondering if you could pick out which one of these describes the way you'd feel about "Kid Pix"?*
- A-33: Umm ... probably that one.

- Q-34: *This one right here?*  
 A-34: Umm Hmmmm.  
 Q-35: *Could you read that?*  
 A-35: I picked this as the best but I did think about other ones.  
 Q-36: *Okay. Now, can you tell me what it is about "Kid Pix" that makes you pick it as your favorite?*  
 A-36: 'Cause you, like, get to do what you want and you draw and make stuff that you want instead of having to do something that, you know, like *Mac Frog*, you have to do it, you know, like what you're supposed to do. I just like *Kid Pix* because I kinda like to draw and make stupid pictures.  
 Q-37: *Okay, but you said you can do anything you want.*  
 A-37: Oh yeah. Basically, you can draw what you want unless you're like doing some specific assignment or something.  
 Q-38: *Umm Hmmmm.*  
 A-38: But usually you can make what you want and use your own ideas to make it.  
 Q-39: *Okay. Do you think that Kid Pix . . . was it something you liked the very first time you tried it or did it take a while to grow on you?*  
 A-39: I liked it. I liked it the first time I tried it.  
 Q-40: *Okay.*  
 A-40: I was probably like in the sixth grade, I think.  
 Q-41: *What sorts of things about "Kid Pix" made you like it?*  
 A-41: That . . . like there's . . . like the . . . when you do the stamps or you can draw whatever you want to draw or you can like do other programs or you can talk into the computer and it repeats what you say, and that's it.  
 Q-42: *Okay. Is there anything about "Kid Pix" that you don't like?*  
 A-42: Not really. Just it's like really colorful and everything. I really like it.  
 Q-43: *Okay. Now, do you think "Kid Pix" would be of value to you in learning science?*  
 A-43: It's just like if . . . like if you were trying to teach us something about condescension or whatever and . . . like in my last year we went to a science club and we drew pictures of like raining, like clouds and stuff from rain, and that helped a lot 'cause you got a better idea of what it does.  
 Q-44: *So, did you draw the pictures, or . . . ?*  
 A-44: Umm Hmmmm. Well, when we got on the computers, we went into *Kid Pix* and drew them.  
 Q-45: *Okay, and how did that help you?*  
 A-45: It helped me understand, like, what it does better 'cause, you know, we went by the book and figured it out on our own and it helped to understand better.  
 Q-46: *Okay. Now, would you want to teach someone else how to use "Kid Pix"?*  
 A-46: It's really not that hard, but if it was like a little kid or something, yeah.  
 Q-47: *Do you think you could teach them?*  
 A-47: Yeah.  
 Q-48: *Do you? Why do you say that?*  
 A-48: Well, 'cause I use it lot and it's like . . . it's not that hard to do.  
 Q-49: *Umm Hmmmm. Okay. Okay. Great. Now, of all the things we've talked about computers so far, is there anything we haven't talked about that you'd like to mention?*  
 A-49: Oh . . . not really . . . just . . . no.  
 Q-50: *Okay. Well, I think we're probably all done.*  
 A-50: That was quick.  
 Q-51: *Yeah. I'm going to shut this off.*

- Q-1: *There we go. Okay, the first thing I'm going to do is I'm just going to put out these words here on these slips of paper and what I'd like for you to do is to see if you can put them together in a sentence, and especially not just any sentence, but a sentence that you would agree with or something that you think is true, something you would consider a fact about science, maybe . . . (long pause) . . . if you need another word, like a copy, I could give you a copy of any of these words.*
- A-1: No. . . (long pause) . . . you don't have "speed" in there?
- Q-2: *You can pretend that there's a "speed" if you want.*
- A-2: I'm finished.
- Q-3: *Okay. Just read it and just put in "speed" wherever you want to put it in.*
- A-3: Okay. Heat temperature flows around objects at a lower speed.
- Q-4: *Okay. Now, I'm going to ask you about a couple of these terms here. This word right here -- temperature -- could you tell me what you think that means?*
- A-4: Like , how . . . how warm is the room or something . . . how far a temperature can get and, that's it.
- Q-5: *Do you have something . . . do you picture something in your mind when you hear the word "temperature"?*
- A-5: A thermometer? A thermometer with like a hot . . . more like a flame at the top and like a minus at the bottom . . . like some ice at the bottom.
- Q-6: *Okay. What about this word here -- heat?*
- A-6: I think of fire . . . like something burning and, let's see, it keeps you warm.
- Q-7: *Okay. This word right here -- flows around?*
- A-7: Like . . . like flows around all the room so, umm, like . . . so if you're in a building, it can flow all around the rooms just everybody can get some heat. It flows around.
- Q-8: *Okay. And then this word here -- speed. You had "lower speed".*
- A-8: See, it'd take time. Say you just turned it on, it would take time for the room to get heated up 'cause it had a speed so that everybody can get some heat at the same time, or something like that.
- Q-9: *Okay. Now, why did you pick "lower" instead of like "higher" or something?*
- A-9: 'Cause like speed is like . . . I mean, heat . . . because I think it travels like real slow so I picked . . . so that's why I picked "lower" speed.
- Q-10: *Okay. I'm going to bring . . . put another word out here -- heat energy. What does this word mean to you?*
- A-10: It means like heat has a lot of energy in it and so like . . . has a lot of energy, so . . . heat . . . nothing.
- Q-11: *Okay. Do you think that "heat energy" is the same or different than "heat"?*
- A-11: It's the same, I think.
- Q-12: *What about "temperature"?*
- A-12: It's different.
- Q-13: *How would it be different?*
- A-13: Because "heat" and "temperature" is like on a . . . is like on a different scale. "Heat" is something . . . heat is, uhh . . . I mean, "temperature", it tells you how much . . . how much the heat can go up to. "Heat energy" . . . it tells . . . "heat" is like some heat in a room. It's different. It's on a different scale.
- Q-14: *Okay. Okay. Good. I'm going to put these away and we'll move on to the next question.*
- Q-15: *What I'd like to ask you, or what I'd like to do is name* (CHANGE TO TAPE 5)

*Like I was saying, I'm going to name three materials and each time I name a material, I'd like for you to tell me whether you think that material would be good for keeping something hot, for keeping something cold, for doing both, or for doing neither. Okay?*

A-15: Okay.

**Q-16** *The first material is aluminum foil.*

A-16: It can keep anything cold. It can do both and if you put it in the refrigerator, it can keep something cold. If you wrap it up in . . . if you put it in the oven, it can keep something hot because it store heat.

Q-17: *Okay. So you were thinking of food, both times?*

A-17: Yeah.

Q-18: *Okay. What is it about aluminum foil that would be able to do either one?*

A-18: 'Cause like aluminum foil is made out of aluminum so it can do like . . . it can do anything. 'Cuz you can heat it up and it won't burn and you can put it in the refrigerator and it won't freeze. It will freeze freeze.

Q-19: *Umm Hmm. Okay. What about wool?*

A-19: Let's see. . . Wool. You can heat it up but you can't freeze it.

Q-20: *Okay. So, why would it work for keeping things warm but not for cold?*

A-20: Say, if you were in a cold place, and you used it as a cloth to keep you warm, it could keep you warm like from winter time, and after . . . but, say, you was in Alaska and it could keep you warm for most of the time but after a while, it starts to freeze up . . .

Q-21: *Umm Hmm.*

A-21: . . . but if you were in a warmer place, it can . . . it still can keep you warm with it.

Q-22: *Okay. Now what about Styrofoam?*

A-22: Styrofoam. It can't do nothing.

Q-23: *Neither one?*

A-23: Umm Hmm.

Q-24: *Okay. Why not?*

A-24: 'Cause it's got strong stuff and it's got little holes in it, so I don't think it can do nothing for you.

Q-25: *Okay. Is there anything in common between aluminum foil and wool that they both can keep things warm?*

A-25: Not that I know of.

Q-26: *Okay. All right.*

**Q-27: Let's talk about computers for a while. Do you use computers any?**

A-27: I use them most of the time when I'm at my cousin's house.

**Q-28: Okay. Good. I'd like for you to think of all the computer software that you've used and try and tell me which one you'd call your favorite?**

A-28: I've used drawing and let's see, it's called, I forgot . . . . (long pause) . . . it's something to do with. . . it's got drawing in it ; and then I use the typing, where you can type anything; and I use letter writing, where you can know how to do your letters and writing and all that. I did math on computers, printing up, and all that.

Q-29: *Okay, good. Let's say, from that list of stuff, you talked about a drawing program, you talked about maybe like a word processing program . . .*

A-29: Yeah, something like that.

Q-30: *. . . and a math program, right? Is that like . . . what does it do, the math program?*

A-30: It'd tell you, say, like, if you do anything wrong and you need help on it, it like . . . it'll fill you in and do some more problems and the problem, a couple problems later, it's there again.

Q-31: *Hmmm. Okay. So, looking at these programs kind of as a whole, did you like . . . did you like them the first time you used them or did it take you a while to kind of learn to like them?*

- A-31: I liked them because they had some games in there, and all that.
- Q-32: *Hmmm. Okay. What specifically did you like about those programs?*
- A-32: Well, it was fun and it was learning at the same time.
- Q-33: *How did you know it was learning?*
- A-33: 'Cause it shows you how you do your math. First, you read it over, and it shows you how you do your math and all that, and then you have . . . and then you get the fun of looking at all the pictures at it, so you speed and all of that.
- Q-34: *Okay. Is there anything about those programs that you don't like?*
- A-34: No . . . not that I know of. Yes there is, like it is short. It is a short program. I don't like that so I have to keep starting it over (chuckle).
- Q-35: *Okay. Do you consider them to be easy to use or hard to use, or in between, or . . . ?*
- A-35: They're easy for me except when it comes to writing on it. I'm like slow at it but I can get it done.
- Q-36: *Okay. Do you think these programs would be of value to you in learning science?*
- A-36: Yeah.
- Q-37: *How?*
- A-37: Say, if you'd want to like know something, you could put the stars and the moons and all that and you can say find out how far a planet is from a different planet. You could find out all about the moons, like who landed on . . . like a meteoroid. You can find out how fast it goes. You can find out how fast light . . . how fast light comes on the earth and all that.
- Q-38: *And how would you do all of that again?*
- A-38: By using the computer. See, you would . . . you'd program it into . . . well, you'd put a certain disk in but you can program it to anything you . . . like . . . that's how fast. . . well, some computers you can ask how fast they go and they can tell you, and all that.
- Q-39: *Okay. Okay. Would you want to teach someone else how to use this stuff?*
- A-39: If I learned, yeah, I'd teach them.
- Q-40: *Okay. Do you think you could teach them?*
- A-40: Uhh, huh.
- Q-41: *Why do you think you'd be able to teach them?*
- A-41: 'Cause you . . . 'cause a computer is easy to use. . . It's like real easy . . . that's why . . . yeah.
- Q-42: *Now, of all the questions I've asked you about computers, is there something else that we haven't talked about that you want to add about them?*
- A-42: No.
- Q-43: *Okay. Then, I think we're done. I'm going ahead and shut this off.*



- Q-1: *Okay. I'm going to go ahead and start. This is by now . . . this is Interview Number 10 for today. What I'm going to do is, I'm going to put out some pieces of paper with some words on it, and what I would like to ask you to do is, try and form a sentence. . .*
- A-1: Form a what . . . oh oh (chuckle) . . .
- Q-2: *. . . try and form a sentence with these words and try to make it a sentence that you agree with, something you'd say was a fact, something that you would say is true. Okay?*
- A-2: Okay. . . (short pause) . . . That wouldn't work.
- Q-3: *If you need . . . you don't have to use all the words . . . or you can use different words . . .*
- A-3: I need another "and".
- Q-4: *Okay. I can do that. I have extras . . . here you go.*
- A-4: Thanks. . . (long pause) . . . Okay.
- Q-5: *Okay. Would you like to just go ahead and read that?*
- A-5: Heat 'n cold . . . heat and cold energy flows out of objects at higher and lower temperatures.
- Q-6: *Okay. Okay. Great. So, what I'm going to do is, I'm just going to ask you about some of these words. This word here -- "temperature", what does this word mean to you?*
- A-6: Umm . . . like . . . (humph) . . . I don't know. Okay. Okay. Like if it was 70 degrees, then you wouldn't know . . . you wouldn't know what number it was if you didn't have that temperature . . . like you wouldn't be able to tell hot it was if there was no temperature, so the temperature tells you the heat or the coldness.
- Q-7: *Okay. What about this word over here -- heat?*
- A-7: Hot air.
- Q-8: *Hot air. Okay. Why would you call . . . why would you pick "hot air"?*
- A-8: Because it's hot and it's air.
- Q-9: *What about this? What is heat versus this term here "cold energy"?*
- A-9: Because cold energy is cold. It's like . . . umm . . . Well, why . . . it all doesn't make sense . . . Cold energy. It can be cold. . . then, it can . . . of course, it could be cold and have a lot of energy . . . ?
- Q-10: *Umm Hmmm.*
- A-10: So, I guess it could be cold air that has energy, or something, I guess . . . and heat is different because it's not hot as cold.
- Q-11: *Now, how could you tell the difference between heat and cold?*
- A-11: Because heat is warm or hot, and cold is cold, like snow.
- Q-12: *Okay. What about this word here -- flows?*
- A-12: Like when you pour pop out of a bottle. It flows into the cup, I guess.
- Q-13: *Can you tell me how heat flows?*
- A-13: When it's coming out the heater, it could flow up into the air, sort of.
- Q-14: *Okay. What about cold?*
- A-14: Well, if it's coming out cold, energy could flow up into the air too, or it could just go like one . . . umm . . . hmmm . . . like when it's really cold outside, when you could see your breath, it flows to the top. It just goes right up to the top. It just like flows up to the top of the sky, I guess.
- Q-15: *Okay. Would you say that this word "temperature" and "cold" and "heat" . . . would you say those are the same or would you say this is different? "Temperature and cold" and "temperature and heat"?*
- A-15: Well, I think it's sorta the same and sorta different?
- Q-16: *Okay, how would it be the same?*
- A-16: 'Cause the temperature could be cold. It could be cold . . . a cold temperature, or it could be a

hot temperature or a heat temperature, but it's sort of different because it's not like . . . the temperature is showing you what how . . . like 70 degrees or something, but cold air just is telling you what kind of temperature it is and hot . . . heat energy . . . heat . . . is just telling you what kind . . . what . . . how . . . what kind of temperature it is, like if it's cold or if it's hot.

Q-17: *Okay. Okay. What I'm going to do is, I 'm going to put these away and I'm going to ask you another question.*

Q-18: ***What I'm going to do is, I'm going to mention a material and I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both, or not doing either one.***

A-18: Okay.

Q-19: ***Okay. The first material is aluminum foil.***

A-19: Can you explain why you would use it, or not, . . . or just answer the question?

Q-20: *You can do both.*

A-20: Well, you could use it . . . I would use it for hot . . . because like when my grandma cooks roast or something, she puts aluminum foil over the food to keep the heat inside of it.

Q-21: *Okay. What about using it for cold. Would you use it to keep something cold?*

A-21: No.

Q-22: *Okay. Do you know why aluminum foil would be good for keeping something hot and not for keeping something cold?*

A-22: Because maybe the aluminum traps the heat in . . . side.

Q-23: *Okay. What about wool?*

A-23: What is wool? Like what does the wool feel like? Like the wool of the sheep?

Q-24: *Yeah.*

A-24: Okay. Umm . . . probably to keep you warm or. . . yeah . . . because if you've got a wool sweater and while they make a sweater that keeps you cold.

Q-25: *Okay. So you would say that you would use wool for keeping something warm?*

A-25: Umm Hmmm.

Q-26: *Okay. Would you ever use wool for keeping something cold?*

A-26: I don't know. I wouldn't.

Q-27: *Okay, now what about Styrofoam?*

A-27: Styrofoam can be used for keeping something cold and hot.

Q-28: *Okay. Now, why would you say that?*

A-28: 'Cause like if you got hot coffee, I guess like maybe the Styrofoam traps the heat inside of the cup and then if its cold, it could trap the heat too. Wait! Wait! Yeah.

Q-29: *Okay. Is there anything that's the same about aluminum foil, and wool and Styrofoam, that they can all keep something warm?*

A-29: Yeah, sorta, because they all can keep heat in.

Q-30: ***Okay. Let's go ahead and talk about computers now. Do you use computers a lot?***

A-30: Umm Hmmm.

Q-31: ***Do you? Okay. I'd like for you to think about all of the different computer software that you've used - - the different programs . . .***

A-31: Say it or just think about it?

Q-32: ***No, just think about it for a second, and tell me if you can tell me . . . pick out which one would be your favorite.***

A-32: Okay, I'm done.

Q-33: *Okay. What would it be?*

A-33: Macintosh.

Q-34: *Okay. What about a program? Is there a program on the Macintosh that you like?*

A-34: Umm. . . like . . . if . . . I don't know what kind of computer is in Mr. Daily's computer

- room.
- Q-35: *Umm Hmmm.*
- A-35: That kind of computer I like. I like the Chooser . . . well, actually, it's the EMS CD Server . . .
- Q-36: *Umm Hmmm. Okay. Is there any particular program that you like that runs on the computer or runs on the CD or anything like that?*
- A-36: . . . I like . . . do it have to be educational or . . .
- Q-37: *Anything at all.*
- A-37: Well, I like *ClarisWorks* because I like writing letters but on the EMS Chooser, I like to play *Monopoly*.
- Q-38: *Okay. So "ClarisWorks" and "Monopoly". Let's see . . . what is it that you like the most?*
- A-38: On the computer?
- Q-39: *Yeah . . . well, about "Claris Works" and "Monopoly". What makes you choose those?*
- A-39: Well, I like the *Monopoly* just because it 's fun, I guess, because it's just fun and I like *Claris Works* because I like writin' letters to my friends, I guess.
- Q-40: *Okay, Now let's . . . did you like these programs like from the very first time you ever tried them or did it take a while for them to grow on you?*
- A-40: I liked them from the first time I tried them.
- Q-41: *Why did you like them right away?*
- A-41: Because *Monopoly* is a lot, you know . . . Of course, you played *Monopoly* before on a board game but it was different playing it on a computer and it seemed like it was more fun playing it on a computer 'cause you got to auction stuff off. And I liked *Claris Works* because you didn't have to write nothing out, you could just type letters, I guess.
- Q-42: *Okay. Okay. What about . . . Is there anything about "Claris Works" or "Monopoly" that you don't like?*
- A-42: Well . . . no.
- Q-43: *Okay. Would you consider "Claris Works" and "Monopoly" hard to use or easy to use or . . . ?*
- A-43: Easy.
- Q-44: *Easy? Why would you call them easy?*
- A-44: Because it didn't really take you no time to learn how to do it. Actually, it don't take you no time. All you have to do is just see how to do it, and I knew how to do it. But, I guess to some people, it's hard. But it can be easy because it's really nothing . . . all you got to do is just open it up and then start typing; or with *Monopoly*, all you gotta do is just start playing the game and type in what you want to do but that's like, it's easy.
- Q-45: *Okay. Now, do you think either of these programs would be of value to you in learning science?*
- A-45: No.
- Q-46: *Okay. Why not?*
- A-46: Because . . . I think it would be of value to learn math from *Monopoly* but . . . and, I guess, for English too because you learn how to spell words better, 'cause you can go to *Claris Works* and check the spelling; and then you can learn math from *Monopoly* but you don't really want to help anyone find it.
- Q-47: *Okay. Now, would you want to teach somebody else to use either "Claris Works" or "Monopoly"?*
- A-47: Yeah, I teach my friends all the time.
- Q-48: *Do you?*
- A-48: Yeah. . . . I won't say her name.
- Q-49: *That's okay. Do you . . . feel like "you" can teach it, then?*
- A-49: Yeah.
- Q-50: *Okay. Why do you think "you" can teach it?*
- A-50: Well, I'm not really like a "teacher" teacher but because like I've been in computers like four times and I always go there and I guess because I know how to do it and it's easy to

learn if you like got a person who'll want to know how to do it, then it's easy.

Q-51: *Hmmm. Okay. Now, of all the questions we've . . . I've asked you about computers, is there something you'd want to add that we haven't talked about?*

A-51: No.

Q-52: *Okay. Then, I think we're pretty much done. I'm going to shut this thing off.*

- Q-1 *... Okay, like I was saying, you can use all of them if you want but you don't have to. If you need extras, I've got extras and I can give you copies. Just try and make a sentence that you would agree with that you think is true, that you would call a fact. . . okay?*
- A-1: Okay . . . sure. . . (long pause) . . . I've got one.
- Q-2: *Okay. Why don't you go ahead and read it.*
- A-2: Heat flows around objects at higher temperatures . . . (indistinguishable).
- Q-3: *Okay. I'm going to ask you about some of these words here. This word here -- temperature -- can you tell me what that word means to you?*
- A-3: Well, temperature is like the way . . . or how hot or how cold it could be. It's like the degree of the air, how cold it is or how hot it is.
- Q-4: *Okay. What about this word here -- heat?*
- A-4: Heat. Well, that's like . . . let's see, it's like air that's hot. It's hot as . . . (indistinguishable) . . . it's not cold but it's hot. I want to say like a "heat wave".
- Q-5: *Would you say that "heat" and "temperature" are the same, or different?*
- A-5: Well, I say they're kinda the same and kinda different because the temperature it rises and the heat drops into this air.
- Q-6: *Umm Hmm.*
- A-6: But temperatures can drop down too but heat cannot drop. It always gets higher unless you get it in a cold glass of water or something.
- Q-7: *Okay. I'm going to pull out one more here. This one -- heat energy -- what do you think this would mean to you?*
- A-7: That's like energy, like from your body heat when you're rubbing your hands together. It causes a flow . . . like when we push . . . how your energy of your hand . . . like it's something like in a bag, like how the energy of your body can shock the bag . . . and hit it like a rubber.
- Q-8: *Okay. Would you say that these two words --heat and heat energy-- would those be the same or different?*
- A-8: Well, more like the same. . .you know, because "raw energy" and "air" well . . . also are the same because they're energy.
- Q-9: *Okay. Okay. Now, what about this word here -- flows. What did you have in mind when you saw . . . when you wrote "flows"?*
- A-9: Well, I like . . . well, like in a room, the heat will kind of like flow around the room and get the . . . kinda just cave in and gets it all warm and stuff. That's about it. It kind of just surround the room with air and then just heats up altogether.
- Q-10: *Okay. All right. Well, I'm going to go ahead and pack these up here. And what I'd like to do is just ask . . . go on to another thing.*
- Q-11: *I'm going to name a material and what I'd like for you to do is tell me, when I name that material, if you think you would use it to keep something hot or to keep something cold, both, or neither. Okay? The first material is aluminum foil.*
- A-11: I'd use it to keep something cold.
- Q-12: *Okay. Why would you do that?*
- A-12: Because my mom does, when she puts stuff in the freezer. So, she do it like that. So, I guess I'd just follow the influence of my mom, so . . . (slight chuckle)
- Q-13: (slight chuckle) . . . *Okay. would you ever use aluminum foil to keep something hot?*
- A-13: Yes. Yes. Yes. Cooked barbecue and stuff. You wouldn't want that stuff to keep all sticky. You put some foil on there and you'd get the same reaction.

- Q-14: *Okay. Now, how does the foil keep things from getting hot? I'm sorry, how does the foil keep things hot?*
- A-14: Well, because energy . . . like from a barbecue pan, the energy of the coals and stuff is rising up. Therefore, it heats the Alcoa Wrap and you put your chicken on there and then it do like that and stuff.
- Q-15: *Okay, now how would aluminum foil keep something cold?*
- A-15: Hmm. I guess just wrapping it around there and keeping everything fresh, keeping all the air in there so it don't get all stale.
- Q-16: *The air that's in where?*
- A-16: In the object . . . like food or whatever it is.
- Q-17: *Okay. You think then . . . when you said, "keep from getting stale", what would stale air do?*
- A-17: Well, you know, I guess it would just make it hard to eat. It would make it cold. It could (indistinguishable).
- Q-18: *The next material would be wool.*
- A-18: Well, I'd use wool to make clothing.
- Q-19: *Okay. Would you use it to keep something hot or cold, or neither, or both?*
- A-19: I'd say, to keep myself warm, I guess. Guess that's hot.
- Q-20: *Umm. Now, what about wool would keep you warm or keep somebody warm?*
- A-20: Well, I guess, it's like a clothing that you have that just covers up your body . . . a shirt or . . .
- Q-21: *Is there anything that's common about aluminum foil and wool that they both keep things warm or hot?*
- A-21: The thing that keeps them together?
- Q-22: *Umm. Hmm.*
- A-22: Well, I guess they're both . . . kinda of like this . . . how can I put it, I guess they both kind of store energy but not really store energy. I'm kinda confused really (chuckle). I'm trying to think about it. I guess like it keeps you warm, like in the winter time, and like protection when it's cold and it's freezing and I guess it'll keep you from getting all frozen.
- Q-23: *Would you ever use wool to keep something cold?*
- A-23: Umm Umm. No.
- Q-24: *Okay. The next material is Styrofoam.*
- A-24: Styrofoam. I don't think I'd use that.
- Q-25: *You wouldn't use it for anything? Why not?*
- A-25: I don't know. It's just like too break . . . too easy to break, or something. It's just . . . I wouldn't use it.
- Q-26: *Hmmm. Okay.*
- Q-27: *Okay. Let's talk about computers now, okay? Do you use computers any?*
- A-27: Yes, during school.
- Q-28: *Okay. I was wondering, if you think about all the computer software that you use -- all the programs that you use, -- if you could tell me which one you would consider your favorite.*
- A-28: Let's see, I would probably figure typing . . . typing.
- Q-29: *Which one?*
- A-29: Typing.
- Q-30: *Typing. Is there a name for that program?*
- A-30: I forgot.
- Q-31: *Is it "Beacon"? Or is it "Mario Brothers"? "Mario teaches typing"?*
- A-31: I don't know.
- Q-32: *But it's a typing program?*
- A-32: It's in Mr. Dake's class.
- Q-33: *Okay. I'm going to show you a list, and if you could just tell me, that typing program that you have in mind, which one of these would best describe it?*

- A-33: I would say, probably this one.
- Q-34: *Could you read that one?*
- A-34: All right. It says: "I picked this one as the best but I did think about the other ones"
- Q-35: *Now, why would you pick that one -- that typing program -- as your favorite?*
- A-35: Well, you know, I guess it's easier to type this. You put the line up there and then you just start typing.
- Q-36: *Okay. Did you like it from the very first time you tried it or . . . ?*
- A-36: No.
- Q-37: *No? (chuckle) It took a while. Why is that? Why did it t take a while?*
- A-37: Well, like, this is something new. You don't really know like what you're doing. You don't want to mess it up and break it like that and so it took me a while to adjust.
- Q-38: *Okay. Is there anything like when you're typing . . . is there anything about the way the program is that you like?*
- A-38: Well, it's just easy to type. It's like a sheet of paper and you have these little lines with side beepers. So, you just know which way you want to start your typing at and you just go ahead and type.
- Q-39: *Okay. Would you consider this program easy to use or hard to use?*
- A-39: I'd say it's more easy . . . more easy. It's got a lot of directions.
- Q-40: *Okay. Let's see . . . well, is there anything about this program that you don't like?*
- A-40: Sometimes, it gets boring . . . (chuckle)
- Q-41: (chuckle) . . .
- A-41: . . . but besides that, no. It's boring sometimes.
- Q-42: *Would you say that this program is of value to you in learning science?*
- A-42: Okay. Yes . . . yes, in a way . . . In a way, I would say that 'cause it's showing me in the distant future the computers and stuff and it's giving me a little look about how to use these . . . (indistinguishable).
- Q-43: *Okay. Now, would you want to teach someone else how to use this program?*
- A-43: No.
- Q-44: *No?*
- A-44: No.
- Q-45: *Why not?*
- A-45: Well, 'Cause see, I wouldn't like want to show them the wrong way 'cause I do things differently, you know. So, I wouldn't want to show them my way and like they'd know that's wrong.
- Q-46: *What do you mean, you do things differently*
- A-46: Like sloppy, like leaving different stuff. So, with computers, I might not go . . . like the last one I might do first or I might write the title last of my story.
- Q-47: *Hm m m.*
- A-47: I would just like write a story and then when I get done, okay, then just put a title on it, and stuff like that.
- Q-48: *Okay. Now, of all the things we've talked about computers, is there anything that you'd want to add to that?*
- A-48: The radio. . . the radio would be nice. The radio.
- Q-49: *Oh really? (chuckle) Okay.*
- A-49: That's be nice having music so you could think more.
- Q-50: *Well, you know, some computers have a CD ROM you can play CD's in it while you're doing stuff. Like, maybe if I see Mr. Dake, I'll tell him about that. That doesn't sound too bad.*
- A-50: I guess that's all right. You just gotta have CD's though.
- Q-51: *Yeah, that's true. With a radio, you don't need CD's. Okay. I think that's it. I'm going to go ahead and shut this thing down now.*

Q-1: *I'm going to put out some of these little words here, and what I'd like for you to do is to just see if you can come up with a sentence out of using some of these words. Now, you don't have to use them all but you can if you want to. What I'd like for you to do is make a sentence that you would agree with or that you would consider a fact, or something you think is true; and if you need extra ones, let me know, I've got extra ones. I've got duplicates of some of them. Okay?*

A-1: . . . (long pause) . . . I have no idea.

Q-2: *Okay. What I'll do is . . . let me just ask you about some of these words, okay? That word right there -- temperature.*

A-2: Umm Hmmm

Q-3: *Could you tell me what that word would mean to you?*

A-3: It's like a degree of hot or cold . . . how hot or cold something is.

Q-4: *Okay. What about this word over here -- this one -- heat energy?*

A-4: I don't know what that is.

Q-5: *Okay. What about this one here -- heat?*

A-5: Heat is how hot something is.

Q-6: *Now, would you say that "heat" and "temperature" are the same, or that they're different?*

A-6: They're kind of the same and different.

Q-7: *Okay, how so?*

A-7: Heat is . . . heat can be a temperature but they're different because cold can also be a kind of temperature.

Q-8: *Okay. Now, let me ask you this. Do you have something that you picture in your head when you see words like "heat" and "temperature"?*

A-8: Like a thermometer.

Q-9: *Is that for . . . for which one?*

A-9: Temperature.

Q-10: *Temperature. Okay. What about for heat. Do you have something in your head that you . . . ?*

A-10: The sun.

Q-11: *The sun, okay. Now, how does something that generates heat, how does the heat get from that thing to us, where we're at, like from the sun?*

A-11: Hmmm. I don't know.

Q-12: *Okay. Does this . . . does this idea that . . . see, we have it here, right here -- flows -- you see some of these words right here like "flows". Do you think that heat flows?*

A-12: Umm Hmmm. Yes.

Q-13: *How would it flow?*

A-13: Like the heat would flow out of the sun and into us. It's like we kind of absorb it . . .

Q-14: *Umm Hmmm.*

A-14: . . . and it'll make us hot.

Q-15: *Okay. Okay. All right. Well, what I'm going to do is, I'm going to put these away and. . . (short pause) . . . I'm going to ask you a couple of . . . another type of question.*

Q-16: *What I'd like to do is this. I'd like to name a material and I'd like for you to tell me if you'd use it for keeping something hot, for keeping something cold, or both, or neither. Okay? The first material is aluminum foil.*

A-16: Umm, to keep something hot or cold. Both.

Q-17: *Both. Now, why would you say both?*



- A-17: Because the heat can stay in because of the aluminum foil or it can make the heat go out of it. It can do either one.
- Q-18: *Okay. Do you . . . Again, do you picture something when you think about aluminum foil keeping something hot or keeping something cold?*
- A-18: Well, the steam gets on it. So, I think about the steam.
- Q-19: *Steam from where?*
- A-19: Like if you cover a pan of food or something, the steam will get on the inside of the aluminum foil and it'll keep it warm.
- Q-20: *How do you know that steam gets inside of it?*
- A-20: Like if you take off the cover of the aluminum foil, you can look at it.
- Q-21: *Okay. Okay. Now, how do you know that aluminum foil will keep something cold?*
- A-21: If you put it . . . like if you just . . . if you have something cold and you put aluminum foil over it and it won't let the cold out.
- Q-22: *Hmmm. Okay. I'm going to name another material -- wool.*
- A-22: It'll keep you warm.
- Q-23: *Okay, how would wool keep you warm?*
- A-23: It won't let water get to you.
- Q-24: *Okay.*
- A-24: . . .and it'll make the heat just stay inside of you. It won't let the heat escape.
- Q-25: *Okay. Would you ever use wool for keeping something cold?*
- A-25: Umm. I don't think so.
- Q-26: *Now, is there something . . . well, let me name another material and then I'll ask that. Another material -- Styrofoam.*
- A-26: I don't know.
- Q-27: *Okay. Let's go back to aluminum foil and wool. Can you think of some way that aluminum foil and wool both work to keep things hot?*
- A-27: . . . (short pause) . . . Can you say that again?
- Q-28: *Sure. You said that . . . aluminum . . . you'd use aluminum foil to keep something hot and you'd use wool to keep something hot. Is there something that's common to aluminum foil and wool that they'd both keep something hot?*
- A-28: I don't know.
- Q-29: *Something about the material or about the way it works to keep things hot -- that's what I'm getting at.*
- A-29: It's kind of like a barrier so it won't let the heat get out of it.
- Q-30: *Okay. Now, you said Styrofoam. You weren't sure.?*
- A-30: Umm Hmmm.
- Q-31: *Right. Does that mean that you really don't know or you don't think you could go either way or . . . ?*
- A-31: I don't think it could go either way.
- Q-32: *Why not?*
- A-32: I don't know . . . You can use it to keep stuff cold, like there's cups that you can buy that have Styrofoam in it to keep something cold or to keep it hot.
- Q-33: *Okay. So, what would you use that for in Styrofoam, or do you know?*
- A-33: I think you can use it for both.
- Q-34: *So, you'd like to make that both, then?*
- A-34: Umm Hmmm.
- Q-35: *Okay. So, for Styrofoam, you think both. For wool, you think hot and for aluminum foil, you think both.*
- A-35: Umm Hmmm.
- Q-36: *Okay. All right.*
- Q-37: *Well, let's talk about computers for a minute. Do you use computers at all?*
- A-37: Umm Hmmm.
- Q-38: *Do you? Think about all of the different computer software that you've used, all the*

***different programs you've used and tell me which one you would think would be your favorite program?***

- A-38: Umm . . . (short pause) . . . umm . . . I don't know. I like just about everything about computers. I work on them just about every day.
- Q-39: *You do?*
- A-39: We just got a brand new one.
- Q-40: *At home?*
- A-40: Umm Hmmm.
- Q-41: *Oh, okay. So, could you pick one particular program then or is there a bunch that you like?*
- A-41: There's a whole lot of them.
- Q-42: *Okay. Can you think . . . could you just tell me two or three of them, or something . . .*
- A-42: Umm.
- Q-43: *. . . without singling one out?*
- A-43: I don't know. We don't really have that much on our computer yet..
- Q-44: *Well, which ones do you use?*
- A-44: We use the word processor.
- Q-45: *Okay and what's that called?*
- A-45: *Microsoft Works.*
- Q-46: *Word. Oh, Works? Works, okay, and what else. Is there any other ones you use?*
- A-46: Umm, I don't think so.
- Q-47: *What about here at school? Is there any other ones you use?*
- A-47: Umm, I don't think so.
- Q-48: *What about here at school? Is there anything that you like here at school?*
- A-48: Umm, Macintosh Basics.
- Q-49: *And what about like anywhere else? Do you ever go to a friend's house or just the mall or stores?*
- A-49: Umm Umm (no).
- Q-50: *Okay. Well, thinking about "Works" and thinking about "Macintosh Basics", why would you say you'd use these. What is it about these that you like?*
- A-50: They're easy to understand. It's like kids can just get in there and they don't have to go and read through a whole bunch of stuff to understand it. They put it in easier terms.
- Q-51: *Hmmm. Okay. So, did you think that's just for kids that they did that, or . . . ?*
- A-51: No, it's for adults too.
- Q-52: *It's for adults too, okay. Did you like these programs from the very first time you tried them or did it take a while to . . .*
- 
- A-52: No, I liked them just as soon as I got to it.
- Q-53: *Did you, why?*
- A-53: Hmmm, they made it easier and it made it fun.
- Q-54: *They made what easier?*
- A-54: The program. It made it easier to understand and it made it easier to use.
- Q-55: *What were you able to . . . what do you find yourself able to do with these programs?*
- A-55: Just about anything.
- Q-56: *Okay . . . like, name a couple of things.*
- A-56: I can write our book reports on it. My sister uses hers for her government work.
- Q-57: *Okay. What about you? What about Macintosh Basics? What do you use that for?*
- A-57: Just to understand the computer more.
- Q-58: *Okay. Is there anything about these programs that you don't like?*
- A-58: Not really.
- Q-59: *No? Would you say that these programs are hard to use, easy to use . . . ?*
- A-59: Easy.
- Q-60: *They're easy. Okay. Do you think that they . . . these programs are of value to you in learning science?*

- A-60: Umm Hmmm.
- Q-61: *Yeah? How so?*
- A-61: Because it'll teach us more. It'll make you understand things. It's like adults, they didn't get as much of a chance to learn about computers, so they made them so that kids, when they grow up, they know how to use them for a new generation.
- Q-62: Okay. Okay. Would you want to teach someone else to use these programs?
- A-62: Umm Hmmm.
- Q-63: *Would you? Why?*
- A-63: I think it'd be interesting.
- Q-64: *Why do you say that?*
- A-64: It's just you would learn more stuff yourself and then for people who don't know how to use it, it would make . . . it would be rewarding to know that you taught them how to do that.
- Q-65: *Do you think you could teach them . . . "you" could teach them?*
- A-65: Umm Hmmm.
- Q-66: *Okay. Why do you think "you" could teach them?*
- A-66: Well, my mom's not very good at it so I've been helping her a lot.
- Q-67: *Oh, okay.*
- A-67: And my sister.
- Q-68: *Interesting. All right. Now, of all the computer stuff we've talked about so far, is there anything that we haven't talked about that you'd like to mention?*
- A-68: Umm Umm (no).
- Q-69: *No? Okay. I think we're pretty much done. I'm going to go ahead and shut this thing down, okay?*

- Q-1: *We're going to go ahead and get started. This is Day Three, First Interview, and to start off with, what I'd like to do is that I'd like to put these words out here and what I'd like for you to do is to take these words and try and form a sentence of some kind. You can see it's going to be science related. If you could form a sentence using some of them or all of them, it's up to you, you can use as many as you want. Just form a sentence that you can ... that you would agree with, that you would think is a fact or that you would think is true.*
- A-1: ... (long pause) ... This is all the sentence I can think of.
- Q-2: *Okay. Let's move these other ones out of the way. Why don't you go ahead and read that?*
- A-2: Heat flows around higher or cold energy.
- Q-3: *Okay. Now, can you tell me what about that you see as true?*
- A-3: Heat is higher than cold 'cause cold ... heat rises and cold just stay down.
- Q-4: *Okay. Now, what would you ... how would you explain this word here --heat?*
- A-4: Heat is warm and hot.
- Q-5: *And what about this over here -- cold?*
- A-5: Cold is like cold ... like freezing or sumpin'.
- Q-6: *Okay. If I were to put this word here -- temperature, what would you call ... what would you call that?*
- A-6: Temperature is like ... temperature is ... I'm not too sure about temperature ... it's like how hot or cold something is, probably.
- Q-7: *Do you think that "temperature" and "heat" are the same or different?*
- A-7: Different.
- Q-8: *Okay, why so?*
- A-8: 'Cause temperature ... heat describes how temperature is, like temperature can be "high" and it can be "low". ... like temperature can be 90 degrees and it can be really hot.
- Q-9: *And what about heat?*
- A-9: And heat is not the same as temperature because heat is like hot and temperature can be cold or hot.
- Q-10: *Okay. I'm going to throw one more word in there and that's this one -- heat energy. What would you think of that word?*
- A-10: Heat give off energy so that'd be heat energy.
- Q-11: *Okay. Do you see "heat energy" and "heat" or "heat energy" and "temperature" being the same or different?*
- A-11: I'd say that "heat energy" and "heat" would be probably the same.
- Q-12: *One more thing I want to ask you about. Is this term here -- flows around. How does heat flow around?*
- A-12: Heat flows in the air. When the wind blows, it flows around.
- Q-13: *Okay. Do you have something in your mind that you picture when you say that? Or can you get a picture of something?*
- A-13: Yeah.
- Q-14: *What would that be?*
- A-14: I get a picture probably of the sun since the sun would give off heat, and of the wind blowing the heat down to earth.
- Q-15: *Okay. All right. I'm going to go ahead and put these away now and I'm going to go ahead to another question.*
- Q-16: *Now, let's say we have a particular material or a wrap of some kind.*
- A-16: Yes.

**Q-17: What I want to know is, if that container or wrap can keep something hot, can it also keep something cold?**

A-17: Yeah, 'cause if it's not on it, it'd be cold.

Q-18: *If it's not . . . I'm sorry?*

A-18: If the wrap is not on it, it'd be cold.

Q-19: *Okay, if the wrap was not on, it would be cold.*

A-19: Yeah.

Q-20: *Okay, how would it keep something hot?*

A-20: If it was hot and you put it over it, it would keep the heat inside it.

Q-21: *Okay. And if it's cold?*

A-21: If it's cold . . . (short pause) . . . and it wasn't on it, it would stay cold.

Q-22: *How would . . . so, what you're saying is that you can wrap something to keep it warm?*

A-22: Yeah.

Q-23: *. . . but you shouldn't wrap it to keep it cold, is that right?*

A-23: Yeah.

Q-24: *Okay. Can you tell me again, maybe in a little more detail, why it would keep something warm when you wrap it? What about that thing that would keep it warm?*

A-24: 'Cause it's sorta like when you have some food and you like is finished eatin' it and it's still warm, you'd probably put something over it to keep it warm so it won't get cold.

Q-25: *Umm Hmmm.*

A-25: Because if you put something over it, the heat can't travel through, so it stay with the food.

Q-26: *Okay, and what happens because it stays with the food?*

A-26: It stays heated.

Q-27: *Okay. Do you have . . . again, do you have a picture in your mind of anything as you're explaining all of this?*

A-27: No.

Q-28: *Can you think of something that would illustrate it to me?*

A-28: Yeah, probably some chicken that's hot and you put foil wrap all over it to keep it warm.

Q-29: *Okay, and what you were saying is that the foil wrap keeps the heat inside?*

A-29: Yeah.

Q-30: *Okay.*

**Q-31: Now, I'd like to talk about computers. Do you use computers a lot?**

A-31: Yeah. I had three of them at home but now I only got two.

**Q-32: Three of them? Wow!**

A-32: Yeah, 'cause I sold one.

**Q-33: (chuckle) Sounds like you're a wheeler dealer here.**

A-33: I got a CD ROM Computer with speakers and I got a Packard Bell Computer.

**Q-34: Wow. Now, I'd like for you to take a minute and think about all the different software that you use and pick, if you can, what your favorite one would be.**

A-34: Favorite software?

Q-35: *Yep. Anything. Anything you use at home or here or . . .*

A-35: I would use the CD ROM for that.

Q-36: *What exactly is that?*

A-36: *Doom I, Doom II, Wolfenstein III . . . that's it.*

Q-37: *Okay. All right. I'm going to show you a scale here. What I'd like for you to do is to pick out a statement that would describe that software you just told me about.*

A-37: Probably this one.

Q-38: *Could you read that one?*

A-38: I picked this as the best, but I don't think about other ones.

Q-39: *Now, can you tell me what it is that makes these your favorite . . . makes you call them your favorite?*

- A-39: Because they write . . . got good graphics but *Wolfenstein*, the graphics ain't that good on that one.
- Q-40: *So, good graphics. Is there anything else?*
- A-40: Good sound effects.
- Q-41: *Good sound effects? Okay. Now, did you like these games from the first time you tried them or did it take a while to grow on you?*
- A-41: The first time I tried it, I liked it but *Wolfenstein*, the first time I tried that, I didn't like it but as I played it and found out some codes for it, it started to get fun.
- Q-42: *Would you consider these games either easy or hard?*
- A-42: Without the codes, it's pretty hard but with the codes, it's easy.
- Q-43: *Okay, what are the codes?*
- A-43: The codes? For *Doom*, to get Gatma (spelling?) who can never die, you can enter IDDQ Din.
- Q-44: *Oh, those kind of codes. Okay, I see what you're saying. I'm thinking about . . . how easy is it to use, like I know on "Doom", you have to change guns, move direction, go faster or slower.*
- A-44: I see. For me it's easy but I see other people try to play and they don't know how to play. They go more like this. They have to look at the keyboard. I pretty much memorize where the keys are on the board.
- Q-45: *Is there anything about those games you don't really like?*
- A-45: . . . (short pause) . . . nope.
- Q-46: *Now, do you think that this software would be of value to you in learning science?*
- A-46: . . . uhh uhh (no).
- Q-47: *No? Why not?*
- A-47: 'Cause science . . . it don't have anything to do with science. I do have some kind of programs that do have science.
- Q-48: *Oh, you do? What are those?*
- A-48: There's like this program that teach you about the different sciences. I forgot the name of it. It's like you could explore stuff and it's got good graphics.
- Q-49: *Okay. Do you think you'd want to teach someone else how to use these games?*
- A-49: Yeah.
- Q-50: *Why not? I mean, why?*
- A-50: Because they're pretty fun games. Some even go over to my house. They have games too. They play them.
- Q-51: *Okay, do you think "you" personally could teach them?*
- A-51: Yeah.
- Q-52: *You do? Why?*
- A-52: 'Cause I'm pretty good at computers. I've been on the computer since I was about 5 years old.
- Q-53: *Really? Wow. Okay. Okay. Great. Of all the stuff I've asked you about computers, is there something else you want to mention that we haven't talked about?*
- A-53: . . . nah ahh.
- Q-54: *Okay. Great. Well, I think that's it. I'm going to go ahead and shut the tape off now.*

Q-1: *I'm going to turn the tape on so we're all ready and rolling. This is our second interview and the first thing I'd like to do is to give you these slips of paper, and what I would ask you to do is to see if you can form a sentence out of these. You don't have to use them all. You could just use some of them but if you can make a sentence that you would agree with or something you would say is true, something you would say is a fact. Okay?*

A-1: Okay . . . (long pause) . . . This might be a sentence. I can't think of any other words.

Q-2: *Okay. Okay. If the tape stops, I'll just take a second to flip it. Go ahead. Read that.*

A-2: Cold flows out of objects at lower temperature.

Q-3: *Okay. Now, let me ask you. Why do . . . why would you say that that is true?*

A-3: Well, I was just trying to make up a sentence that makes . . .

Q-4: *Okay, let's look at each . . . at some of these words here. What about this word here -- temperature. What is that? What does that mean to you?*

A-4: Like how does it feel in the room where you're at. How does it feel?

Q-5: *Okay. What about this word here -- cold?*

A-5: Like feeling a breeze or something.

Q-6: *Okay and do you have something in mind when you're saying these things? A picture maybe?*

A-6: Yeah maybe like the snow last night. It was cold.

Q-7: *Okay. What about this word here -- flows -- right here. What does that say to you?*

A-7: Like coming out of a wind or something.

Q-8: *Why did you pick that?*

A-8: 'Cause it comes out the vents, because like air condition.

Q-9: *Okay. I'm just going to throw in one more word here . . . and this one here -- heat energy -- does that mean anything to you?*

A-9: Huh Uhh.

Q-10: *Okay, what about this word here -- heat?*

A-10: Heat?

Q-11: *What would that mean?*

A-11: It would mean warm. It's hot. You'd use that for like a furnace and stuff.

Q-12: *Okay. Okay. Great. I'm going to go ahead and put these away now. And what I'm going to do is, I'm going to ask you a second question. Okay?*

Q-13: *Now, let's say that we have some kind of a container or a material or a wrap of some kind and my question would be, if that material or wrap can keep something hot, can it also keep something cold?*

A-13: Yes.

Q-14: *Okay. Now, how would it do that?*

A-14: If it was wrapped up in foil?

Q-15: *Any container or wrap.*

A-15: It would be just like a thermos, probably . . .

Q-16: *Okay, so how would . . . I'm sorry, say that again.*

A-16: It would just be like a thermos.

Q-17: *Okay. How would you keep something hot with a wrap or material?*

A-17: It would have to be hot already and you would just wrap it up.

Q-18: *Okay.*

A-18: Put it inside the jar and keep something over it might keep it hot.

Q-19: *Okay. How about if you want to keep something cold? How would it work?*

- A-19: It'd be . . . you might have something cold you could put in the freezer or refrigerator.
- Q-20: *Do you . . . again . . . do you have some kind of picture in your mind as you're saying all this? What would that be?*
- A-20: Pudding like you could have it in the refrigerator. You could have it up in the freezer so you can keep it or you can just like set it out. Sometimes, people have the heat on so room temperature can keep it warm like that.
- Q-21: **Okay. Let's talk about (CHANGE TO TAPE 6) computers. Have you ever used a computer?**
- A-21: A little.
- Q-22: **A little?**
- A-22: A little.
- Q-23: **Okay.**
- A-23: We just got one at the house.
- Q-24: **Oh, Okay.**
- A-24: I haven't started working it just yet and I don't know much about it.
- Q-25: **Well, if you can, just think about the different software that you use or the different programs that you've used on a computer, and tell me if you could pick one that you would call your favorite right now.**
- A-25: Let's see. Can it be like a game?
- Q-26: *Anything. Yeah.*
- A-26: *Math Blasters.*
- Q-27: *"Math Blasters". Okay. I'm going to show you a scale and I'd like for you to tell me which one of these would best describe what you think of "Math Blasters"?*
- A-27: . . . (long pause) . . . this one right here.
- Q-28: *Would you read that?*
- A-28: I picked this as the best, but I did think about the others.
- Q-29: *Okay. What is it that you like about Math Blasters that made you call it your favorite?*
- A-29: I did like the math on there plus, you can play games. In those games, you've got to solve a math problem so you can jump higher.
- Q-30: *Okay. Do you think "Math Blasters" is hard to use or do you think it's easy?*
- A-30: Easy. You can play it on higher levels though and in between, I guess.
- Q-31: *Okay. I was thinking about rather than how hard it is to actually play the game but how hard it is to use it, like to know where the keys are and knowing the instructions for playing and stuff.*
- A-31: Oh that? That's easy.
- Q-32: *Is it?*
- A-32: Yeah.
- Q-33: *Is there anything that you don't really like about it?*
- A-33: Uhh Uhh (no)
- Q-34: *Is there anything you especially like about it?*
- A-34: Uhh Uhh (no).
- Q-35: *Okay. Now, do you think that that program would be of value to you in learning science?*
- A-35: This right here?
- Q-36: *"Math Blasters"?*
- A-36: Yes, because it teaches you about math.
- Q-37: *Okay, now, how would that be valuable to you in learning science?*
- A-37: Well. It's a different subject, math from science.
- Q-38: *Well, if you think it would be helpful, you can tell me how it would be helpful?*
- A-38: Oh, I wouldn't be able to.
- Q-39: *Okay, would you want to teach someone else how to use "Math Blasters"?*
- A-39: Well . . . no, not right now.
- Q-40: *No, not now? Why not?*



A-40: 'Cause they're probably learning the same thing in school.

Q-41: *If someone wanted to learn it, do you think "you" could teach them "*

A-41: . . . {indistinguishable} . . .

Q-42: *Why do you say that?*

A-42: . . . {indistinguishable} . . .

Q-43: *Okay. Of all the things we've talked about computers so far, is there anything that you wanted to add to that?*

A-43: . . .{indistinguishable} . . . can't just teach . . . (indistinguishable)

Q-44: *No? Okay, that's great. I think we're all done.*

**Q-1:** *Okay, here we go, third interview of the day. And what I'd like for you to do is, I'm going to put these words out here and what I'd like for you to do is to tell me if you can make a sentence, using some or all of these words, and it would be something that you would consider a fact, something that you would consider to be true, or something that you would agree with. You don't have to use them all but if you want to, you can.*

A-1: . . . (long pause) . . . Okay.

Q-2: *All right, do you want to go ahead and read that?*

A-2: Heat flows into and stays in objects at higher temperature.

Q-3: *Okay. What I'd like to do is ask you a little bit about some of these words that you used? What is this word here -- temperature -- mean to you?*

A-3: It means how hot or cold something is.

Q-4: *Okay. What about this word here -- heat?*

A-4: It's what makes something hot. If you heat something, you make it hot.

Q-5: *Okay, and what about this word here -- flows?*

A-5: It enters into and joins it together, like if your water . . . the heat and the water mix and then it boils.

Q-6: *Okay. Okay. I'm going to pull out another word here, that's this one here -- heat energy. What does that mean to you?*

A-6: That means energy that's conducted through heat.

Q-7: *Okay. Now, if I were to put "heat energy" here next to "heat", would you say these are the same or different?*

A-7: I'm going to say different.

Q-8: *Okay, how would they be different?*

A-8: Well, heat is the concept of hot, in heatin' something. This is the actual energy that heat produces.

Q-9: *Okay. Okay. And comparing heat energy and temperature, would you say they are the same or different?*

A-9: I would say they're different.

Q-10: *Okay. Why would you say that?*

A-10: Because heat energy most likely controls what the temperature is.

Q-11: *Okay. All right, I think that what I'm going to do is, I'm going to collect this and move this out of the way and we'll move on to another question.*

**Q-12:** *The second thing I want to ask you is, I want to ask you, do containers or wraps that help keep hot objects hot also help keep cold objects cold?*

A-12: Yes.

Q-13: *Okay, why would you say that?*

A-13: It's worked before. If you take a thermos and put something cold in it, it keeps it cold. If you put something hot in it, it keeps it hot.

Q-14: *Now, can you tell me why you think a thermos does that?*

A-14: Hmmm. No.

Q-15: *Can you think of other things that do the same thing like a thermos?*

A-15: Like saran wrap or aluminum foil.

Q-16: *Okay. Can you tell me how those work to keep things hot or cold?*

A-16: Both . . . no . . . aluminum foil is a . . . aluminum is both a conductor of heat and cold so, therefore, it keeps hot things "hot" and cold things "cold".

Q-17: *Now, what would you mean by a "conductor"?*

- A-17: It means heat and cold, once they're in there, it tends to keep it unless it's brought into a warmer atmosphere.
- Q-18: *Okay. Okay.*
- Q-19: *Let's talk about computers for a minute. Do you use computers a lot?***
- A-19: Yes, whenever I can.
- Q-20: (chuckle) *I want you to think about all the computer software that you've used and tell me what you would consider your favorite program to be?***
- A-20: Probably getting onto the Internet.
- Q-21: *Okay.*
- A-21: The software that gets you into the Internet.
- Q-22: *Okay. Do you have a . . . I mean, there's several software that does that. Can you pick one or . . . ?*
- A-22: I like *UNIX*.
- Q-23: *Okay. So, you like just the "UNIX" operating system?*
- A-23: Yeah.
- Q-24: *The commands . . .*
- A-24: Yeah.
- Q-25: *. . . and the things you can do with it?*
- A-25: Yeah. I can't stand VAX .
- Q-26: (chuckle) *Okay. Can I show you this scale here and tell me where you would rank "UNIX". Which one of these do you think would apply?*
- A-26: I would say that it's by far the best one I've used.
- Q-27: *Now, could you tell me what you like about "UNIX". . . why you picked it?*
- A-27: It's more user friendly.
- Q-28: *Umm Hmmm.*
- A-28: It's easier to access and you don't get lagged as much like you would on VAX.
- Q-29: *Yeah. I was just going to say, could you just tell me, just especially for the sake of the tape, what you're comparing it to?*
- A-29: VAX, the VAX operating system.
- Q-30: *Through BMS?*
- A-30: Yeah.
- Q-31: *Okay. So why do you compare those two? I mean, why not "UNIX" to something else?*
- A-31: 'Cause those are the only two I've used.
- Q-32: *Okay. What specific features, if you could just name some features, I know you talked about lagging, are there any other things?*
- 
- A-32: Not really. Basically, lag is the main reason why I like one over the other.
- Q-33: *Did you like "UNIX" from the very first time you tried it or did it take a while to grow on you?*
- A-33: It took a while . . . because I was so used to using the VAX System. It took a while for me to get used to the way *UNIX* worked.
- Q-34: *Okay. do you think that "UNIX" is easy to use now?*
- A-34: Yeah, easy.
- Q-35: *Okay, is there anything you don't like about "UNIX"?*
- A-35: Not really.
- Q-36: *Well, that's pretty good. A lot of people have a lot of gripes about it. (chuckle) That's why I was asking. Do you think that "UNIX" would be of value to you in learning science?*
- A-36: Yes.
- Q-37: *How so?*
- A-37: It could . . . it would be able to get you on to like question and answer bulletin boards and stuff.
- Q-38: *Okay. Would you want to teach someone else how to use "UNIX"?*
- A-38: I could.

Q-39: *Okay. Why?*

A-39: *Just be . . . I like the computer so I would think it was fun and I'd be able to get to know the computer better and could have other people learn how to use the computer.*

Q-40: *Okay, why do you think you could teach them?*

A-40: *I don't know. I've worked . . . I've used it for maybe two, three, four months.*

Q-41: *Okay. Now of all the stuff we've talked about computers. I want to ask you one more thing? What sorts of things do you do when you're on the "net"?*

A-41: *I basically go to the talk channels and sit and talk to people around the country.*

Q-42: *Okay. All right. Is there any one place in particular, any one . . ."*

A-42: *Disney.*

Q-43: *"Disney". Okay. (chuckle) Is there anything else, of all the stuff we've talked about computers so far, is there anything you want to add to that?*

A-43: *Not really. Games are fun.*

Q-44: *Okay. Okay. That sounds good. That's it. I'm going to go ahead and shut this thing off now.*

- Q-1: *Okay, here we are. Interview Number 4 and what I'm going to do is, I'm going to lay out some words here and what I'd like for you to do is, see if you can put together a sentence from these. Now, you don't have to use all of them. You can use all of them if you want to but put together a sentence that makes sense to you, something that you would consider to be true, something you'd consider to be a fact, something you'd agree with . . .*
- A-1: Cool.
- Q-2: *Okay?*
- A-2: . . . (short pause) . . . Let's see. I don't think I know anything about heat or energy, or anything about temperature.
- Q-3: *Okay. Well, let me ask you some of these . . . about some of these things. What do you think . . . ?*
- A-3: Oh, okay, I know something about it . . . let's see . . . I have the word "temperature" but I don't have the rest of the words.
- Q-4: *What words did you put in there?*
- A-4: Heat and cold are temperatures.
- Q-5: *Heat and cold are temperatures. Okay. That sounds good. Now, why would you say that that's something you agree with?*
- A-5: Because it . . . when it's the temperature, you should be cold or it should be hot.
- Q-6: *What exactly would you say a temperature is?*
- A-6: How hot or cold something is. How hot it is how to use temperature in a sentence.
- Q-7: *Okay, how about this word here -- heat? What would you say that is?*
- A-7: Hot. Hot air. Hot weather.
- Q-8: *Okay. Are there things that you're picturing in your mind as you're saying this?*
- A-8: Summer's hot.
- Q-9: *Okay. What about this word here -- heat energy?*
- A-9: Heat energy?
- Q-10: *Umm Hmmm.*
- A-10: Like a vent, or a heater to heat up a home.
- Q-11: *Okay. Now, you've got like a heater or something in one place and you're standing somewhere else, how does the heat from that heater get to you?*
- A-11: It flows through the air.
- Q-12: *Okay. By "flows", what do you mean by "flows"?*
- A-12: Well, the rays from the heat just moves around and heats up the room.
- Q-13: *Okay. Do you think that . . . that these words "heat energy" and "heat" and "temperature" can all be used in place of each other? Are they all kind of the same thing or do you think they're different?*
- A-13: "Heat energy" and "temperature" and "heat"? They're probably the same.
- Q-14: *Okay. You think they're all kind of the same?*
- A-14: Umm Hmmm.
- Q-15: *Okay, why would you say that?*
- A-15: Because it all has something to do with temperature.
- Q-16: *Okay. All right. I think I'll go ahead and put these away now and I'm going to go on to something else.*
- Q-17: *What I'd like to do is just ask a simple question and get a simple answer.*
- A-17: Umm Hmmm.
- Q-18: *What I'd like to ask is, if you have a material or a wrap of some kind, and you want to . . . can you use that material or wrap to keep a hot object hot and to keep a cold object*

***cold, or just one or the other?***

- A-18: You can use it for both, like a foil. . .
- Q-19: *Go ahead.*
- A-19: A foil can keep the cold air in or the foil can keep the heat in, if you wrap it around.
- Q-20: *What is it about the foil that does that?*
- A-20: The aluminum? I don't know.
- Q-21: *So, if you had something else, could you use . . . could something else work just as well? Or is there something special about aluminum?*
- A-21: I don't know. I don't know.
- Q-22: *What about for. . . well, I guess I should say again, did you have a picture in your mind? Were you thinking of something in particular when you mentioned that?*
- A-22: No.
- Q-23: *Could you come up with an example of something that would . . . ?*
- A-23: Like a baked potato being baked on a grill, or something, wrapped in aluminum foil . . . or an orange. You can wrap the orange up to try to keep it cold.
- Q-24: *Okay. Now, if you have a baked potato and you wrap it in aluminum foil, what do you think the aluminum foil is going to do to keep it warm?*
- A-24: Keep the heat in.
- Q-25: *Okay. What about for the orange?*
- A-25: Keep the coldness in . . . the moisture.
- Q-26: *Okay. The coldness or the moisture, or both?*
- A-26: Both.
- Q-27: *All right. Let's talk about computers for a minute. Do you use computers?***
- A-27: I used to have one at home then my sister borrowed it for a while.
- Q-28: *Can't blame her. Think about all the different computer software that you've used and tell me what you would think your favorite program is?***
- A-28: Oh. It's been a long time since I've used a computer . . . (short pause) . . . Ones that had a lot of games and stuff like that.
- Q-29: *Okay. Is there any ones you can remember the names of?***
- A-29: uhh uhh (no).
- Q-30: *I want to show you this . . . this sheet here. You just pick out which one of these best describes those games that you were talking about.***
- A-30: That one. I picked this as the best, but I did think of other ones.
- Q-31: *Okay. Now, why did you pick those games out as your favorite?*
- A-31: Because I like to play games on computers and stuff.
- Q-32: *Okay. What was it about those games that made them your favorite?*
- A-32: Because they made me keep going for it to get the highest score and stuff. It made me keep going for it.
- Q-33: *Okay. Was there anything that you really liked about those games? The way it was put together, or the way it looked, or anything like that.?*
- A-33: Umm. The way the game played. The way the game was set up.
- Q-34: *Did you think it was hard to use? It was easy to use?*
- A-34: Easy.
- Q-35: *Why would you say that?*
- A-35: Because . . . I don't know. I just know how to use the computer.
- Q-36: *Okay. What . . .*
- A-36: Like games and stuff.
- Q-37: *Like what sorts of things were you able to do? Or what did you have to do?*
- A-37: I played like *Wheel of Fortune* and *Jeopardy* and some other games and stuff. All I had to do was push buttons on the thing that types in stuff.
- Q-38: *Okay. Were there anything about those games that you didn't like?*
- A-38: Where the computer cheated.

- Q-39: *Where what?*  
A-39: *Where the computer cheated.*  
Q-40: *How did it cheat?*  
A-40: *They already knew the answers but they act like they didn't.*  
Q-41: *Oh, I see. Now, do you think that these programs would be of value to you in learning science?*  
A-41: *Hmmm. Probably.*  
Q-42: *How so?*  
A-42: *Umm. I do not know (chuckle).*  
Q-43: *Okay. Would you want to teach someone else how to play those games?*  
A-43: *Umm Hmmm. I can play on the computer all the time.*  
Q-44: *Umm. Why?*  
A-44: *Because . . . (chuckle) . . . so I won't have to play the computer so I have another challenger instead of the computer so I won't have . . .*  
Q-45: *Okay. Do you think you could teach?*  
A-45: *Me?*  
Q-46: *Umm Hmmm.*  
A-46: *Teach what?*  
Q-47: *Someone else how to play those games?*  
A-47: *Umm Hmmm.*  
Q-48: *Why do you think you can do it?*  
A-48: *Because I know how to play. Because I know how to . . . I know what I can do and what I'm supposed to do.*  
Q-49: *Okay. Now, of all the stuff we've talked about computers, is there anything that we didn't talk about that you'd want to mention?*  
A-49: *No.*  
Q-50: *Okay. I think that's it then. I'm going to call in another interview.*

- Q-1: *Okay, we are on Interview Number 5. The first thing I'm going to do is, I'm going to put out these papers right here, these slips of paper, and what these are supposed to do . . . these are supposed to . . . or hopefully you can put these together in a sentence of some sort. You don't have to use them all. You can use them all if you want to but just construct a sentence that you would agree with, something that would make sense, something that you would consider to be true or a fact. Okay? . . . (very long pause) . . . If you need extra words or copies, I can give you copies.*
- A-1: This is probably all I can make.
- Q-2: *Okay. Just go ahead and read that.*
- A-2: Cold temperature flows out of lower heat and stays in cold energy.
- Q-3: *Okay. That's kind of an interesting arrangement. You have half here and half over here. Let me ask you . . . I'm going to slide these over here . . . what does this word here -- temperature -- mean to you?*
- A-3: What does it mean?
- Q-4: *Umm Hmmm.*
- A-4: It means how hot or how cold. It tells you what the temperature is.
- Q-5: *Okay. What about this word here -- heat?*
- A-5: Warm and . . . how hot it is.
- Q-6: *Now, do you see "heat" and "temperature" as being the same or different?*
- A-6: Different.
- Q-7: *How are they different?*
- A-7: Because temperature will tell you how hot or how cold it is.
- Q-8: *And what about "heat"?*
- A-8: Heat tells you it's warm.
- Q-9: *Okay. You use this over here . . . this term over here -- cold energy. Can you tell me what you'd say that means?*
- A-9: It means . . . when it's . . . sometimes it can be hot out and the cold energy can go around the heat and make it something like the cold winds and all that. I think. I don't know.
- Q-10: *That's okay. I'm just curious. So, you were comparing "cold energy" to like "winds", just now?*
- A-10: *Umm Hmmm.*
- Q-11: *Is that a picture you have in your head of something that has cold energy?*
- A-11: Yeah.
- Q-12: *Okay. What would you call this over here -- heat energy?*
- A-12: Form of air, I guess . . . I don't know.
- Q-13: *Okay. Do you have some picture in your mind of that? When you think of that?*
- A-13: *Umm Hmmm.*
- Q-14: *What about this word here that you used -- flows? What is that?*
- A-14: I mean it flows around and . . .
- Q-15: *In what way?*
- A-15: In what way?
- Q-16: *Yeah. How does it flow?*
- A-16: Well . . .
- Q-17: *Okay. Sounds good. I'm going to go ahead and roll these up and move on to the next question.*
- Q-18: *What I'm going to do is, I'm going to name some materials. What I would like for you to do is, when I name a material, if you could tell me if you would use it for keeping*



- something hot, for keeping something cold, for doing both, or for doing neither? Okay?*
- A-18: Umm Hmmmm.
- Q-19: Okay. The first material is aluminum foil.**
- A-19: . . . (short pause) . . . what did you say that you . . . ?
- Q-20: *Keep something hot, keep something cold, do both or do neither?*
- A-20: Both.
- Q-21: *Okay.*
- A-21: Because you can wrap something up and put it back in the freezer or you can help to keep it warm in the microwave.
- Q-22: *Okay, so you got these pictures in your head that you're describing right now?*
- A-22: Umm Hmmmm.
- Q-23: *Umm. How do you think aluminum foil works to do that?*
- A-23: I don't know.
- Q-24: *Let's look at another material. How about wool?*
- A-24: . . . (short pause) . . . keep it hot.
- Q-25: *Okay . . . how do you think wool would keep something hot?*
- A-25: 'Cause it's thick and . . . I don't know, it's just warm.
- Q-26: *Okay. Do you think wool could ever be used to keep something cold?*
- A-26: Umm Hmmmm.
- Q-27: *Okay. So, you'd say wool could go either way, then?*
- A-27: Umm Hmmmm .
- Q-28: *Okay. How do you think wool could keep something cold?*
- A-28: I don't know. It depends.
- Q-29: *What would it depend on?*
- A-29: . . . (short pause) . . . I don't know (chuckle).
- Q-30: *Okay. That's okay. What about Styrofoam?*
- A-30: Styrofoam?
- Q-31: *Umm Hmmmm.*
- A-31: Both.
- Q-32: *Both? Okay. Why would you say both?*
- A-32: Because let's say you have a Styrofoam cup and you put something warm in it, it's going to stay warm. You put something cold in it and it's going to stay cold.
- Q-33: *Okay. So, basically for all three of these, you said any one of them could keep something hot or keep something cold?*
- A-33: Umm Hmmmm.
- Q-34: *Okay.*
- 
- Q-35: Let's talk about computers now, okay? Do you use computers?**
- A-35: Umm Hmmmm.
- Q-36: Do you use them a lot?**
- A-36: Uhh Uhh (no).
- Q-37: A little? Some ?**
- A-37" Umm Hmmmm.
- Q-38: Yeah? I'd like for you to think (CHANGE TO SIDE B OF TAPE 6) about all the different computer software that you've used and tell me if you could pick one that you would call your favorite?**
- A-38: Like printing, you mean the disk?
- Q-39: *Yeah.*
- A-39: Printing, writing, you know?
- Q-40: *Okay. do you think you can remember the name of the program at all?*
- A-40: Uhh, uhh (no).
- Q-41: *Is it something you use here at school, or at home, or somewhere else?*

- A-41: At my other school (indistinguishable)
- Q-42: *Okay. What can you do with those disks?*
- A-42: You can write essays and draw . . . (slight pause) and you can print out stuff. Just a whole bunch of things.
- Q-43: *Okay. Now, I'm going to show you a scale here and if you could tell me where on this scale these printing and writing programs . . . where would you rank them?*
- A-43: . . . (pause) . . . this one.
- Q-44: *Okay. "the only one you've ever used"?*
- A-44: Umm Hmmm.
- Q-45: *Okay. Was there anything you liked about these?*
- A-45: About what?
- Q-46: *Like the printing and the writing stuff.*
- A-46: That's good when I need to do my essay or something.
- Q-47: *How is that?*
- A-47: Because it's easier to type than write.
- Q-48: *Oh, yeah? Hmmm. Why do you . . . is that just the way you are? Or is there something . . .*
- A-48: Umm Hmmm.
- Q-49: *Okay. Is there something about these programs that you don't like?*
- A-49: Uhh Uhh (no).
- Q-50: *No? Do you consider them to be easy to use or hard to use or . . . ?*
- A-50: Sometimes they can be easy and sometimes they can be hard.
- Q-51: *When are they easy?*
- A-51: Hmmm?
- Q-52: *When are they easy?*
- A-52: When you know what you're doing and you're used to it, and then they put you on a work table and you don't know how to work it and then so . . .
- Q-53: *And then they get hard. Okay now. . . did you . . . or do you . . . do you think these programs would be of value to you in learning science?*
- A-53: Uhh uhh (no).
- Q-54: *Why not?*
- A-54: I don't know.
- Q-55: *What about . . . do you think you'd want to teach someone else how to use them?*
- A-55: Umm . . . (short pause) . . . yeah, probably, I don't know.
- Q-56: *Okay. You know, if you had someone who wanted to learn, do you think you could teach them?*
- A-56: If I knew how to do it.
- Q-57: *If it was one of these that you've used before, do you think you could teach somebody?*
- A-57: Umm Hmmm.
- Q-58: *Why do you say that?*
- A-58: Because I already have my skills done in it and now I know how to work it and do everything with it and I can show somebody else.
- Q-59: *Okay. Now, of all the stuff we've talked about computers so far, is there anything that you wanted to add to any of that?*
- A-59: Uhh uhh (no).
- Q-60: *No? Okay. Then, I think we're done. I'm going to go ahead and turn this off.*

**Q-1:** *This is Interview Number 6 for today and the first thing I'd like to do is put out these words and what I'd like for you to do is see if you can construct a sentence out of these that you would agree with, or that you would consider a fact, or something that you would consider to be true, okay? Now, you don't have to use them all. You can just use some of them, if you want. If you want to use them all, you can use them all and if you want a copy of any one, let me know and I can give you a copy.*

A-1: . . . (long pause) . . . chips . . . (short pause) . . .

Q-2: *Okay, why don't you go ahead and read it.*

A-2: Heat energy flows into and cold energy flows out of objects at higher temperature.

Q-3: *Okay. I'm going to ask you about some of these words that you used. This word here -- temperature -- what does this mean to you?*

A-3: The measurement of how much heat energy there is in a room or . . . or outside, or something like that. Like in a kettle, if you want to know how hot it is, like if it was at the boiling point which would be about 247 Fahrenheit, I think.

Q-4: *Okay, What about this word over here -- heat energy?*

A-4: Umm Hmmm.

Q-5: *What does that mean to you?*

A-5: Heat energy. . . well, I'm really . . . I'm really not that familiar with heat energy. I know kinetic energy. I know electrical energy but heat energy, I'm not very . . . well, if I . . . I do know temperature and the energy but I don't know exactly what it is and how it works.

Q-6: *Okay, what if I were to get this word out here -- heat. What could you tell me about heat?*

A-6: Heat is a bombardment of heat energy into something, I guess.

Q-7: *Okay. What about this word here -- flows. You used it here and here. What do you mean by "heat and energy flowing" and "energy flowing"?*

A-7: Well, I think heat energy is just some sort of polarized energy that raises the temperature and cold energy slowly . . . is less and less inside an area.

Q-8: *Okay. Would you consider heat and temperature to be the same or different?*

A-8: Hmmm . . . Well, I think temperature is just a measurement of how much heat there is in an area and heat is just some sort of phenomena.

Q-9: *Okay. Okay. That's . . . I'm going to go ahead and take these out now.*

**Q-10:** *The next thing I want to ask you is . . . I'm going to name some materials, okay. And what I'd like for you to do is tell me when I name a material if you would use that material for keeping something hot. . .*

A-10: Umm Hmmm.

Q-11: . . . *keeping something cold. . .*

A-11: Umm Hmmm.

Q-12: *Or doing both.*

A-12: Umm Hmmm.

Q-13: *Or neither.*

A-13: Okay.

Q-14: *Okay? The first material is aluminum foil.*

A-14: Keeping it hot.

Q-15: *Okay. Why would you say that?*

A-15: Well, I know that metal is a good conductor of heat and that's about it.

Q-16: *So, why would a good conductor of heat be good for keeping something hot?*

A-16: It would keep heat in one spot.

- Q-17: *Okay. How would it do that?*  
A-17: I really don't know.  
Q-18: *Okay. Do you think aluminum foil could be kept for . . . or used for keeping things cold?*  
A-18: Uhh Uhh, I don't think so.  
Q-19: *Okay, let's go to another material -- wool?*  
A-19: Neither.  
Q-20: *Neither. Okay. Why would you say that?*  
A-20: Well, first of all, wool has a lot of folds in it and it's got a lot of pores . . . (conversation is interrupted by a female voice checking on the student's whereabouts so that he doesn't get points off and then asking if he needed her to which the student replied "no".) . . . it has a lot of pores and I guess heat and cold energy could go through at the same time.  
Q-21: *Okay, so you're saying wool wouldn't be good for either one.*  
A-21: Naah. Unless it was used for homeoferbic(sic) beings, such as ourselves.  
Q-22: *Okay. Why would it be good for that?*  
A-22: Hmmm . . . because it would slightly hold the heat inside.  
Q-23: *Hmmm, okay. I'm going to name another material - "Styrofoam".*  
A-23: Both.  
Q-24: *Okay. why do you say that?*  
A-24: Hmmm. Because that's what they use in thermoses and I really. . . I guess because the pores are so close that heat energy can't get through as well.  
Q-25: *Umm Hmmm. Okay. How would it work for keeping something hot?*  
A-25: The heat energy couldn't bounce out.  
Q-26: *Okay. Now, is there something similar about aluminum foil and Styrofoam that they would both keep things hot?*  
A-26: Aluminum foil and Styrofoam have very small pores.  
Q-27: *Okay, and so the heat couldn't get out?*  
A-27: Umm Hmmm .  
Q-28: *Okay. All right...*  
  
**Q-29: Well, let's talk about computers for a minute.**  
A-29: Okay.  
**Q-30: You like that, huh?**  
A-30: Umm Hmmm.  
**Q-31: Okay. Do you use computers a lot?**  
A-31: Oh yes.  
**Q-32: Do you? Okay. I'd like for you to think about all the different software that you've used and tell me, if you could, what your favorite program might be?**  
A-32: . . . (short pause) . . . just give me a second here.  
**Q-33: Okay.**  
A-33: Probably my CD-ROM Game *Dune*. You know, the Dido De Lorenti's film?  
  
Q-34: *"Dune". Yes, I saw that. I read the book too.*  
A-34: Really? All of them?  
Q-35: *I'm asking the questions.*  
A-35: (Chuckle).  
Q-36: (Chuckle). *We can talk about it later, off the tape.*  
A-36: Here Here!  
Q-37: *I'm going to show you a scale and I'd like for you to tell me where you think "Dune" would. . . . which one of these would describe "Dune".*  
A-37: Right about here.  
Q-38: *The second one? How . . . could you read that?*  
A-38: I picked this as the best but I did think about the other ones.  
Q-39: *Okay. Now, can you tell me what it is about "Dune" that made you pick it out?*  
A-39: Well, first of all, it's probably the most interactive game I've ever tried.

- Q-40: *Okay, now what do you mean by "interactive"?*  
A-40: Well, well, you can actually do something that would be different from the movie and it would have an impact on what happens in the future.
- Q-41: *Okay, okay. Now why does that. . . or why do you like that feature?*  
A-41: Well, it's almost virtually doing something for real.
- Q-42: *Okay, why do you say it's almost like doing something for real?*  
A-42: Well, because it isn't doing something for real (chuckle).
- Q-43: *Okay. Did you like "Dune" from the very first time you tried it? . . .*  
A-43: Yes.
- Q-44: *. . . or did it take a while for it to grow on you?*  
A-44: No, I liked it.
- Q-45: *Okay. Is there anything you like in particular about the way the program is put together or the way it appears?*  
A-45: Well, it has lot . . . a large assortment of accessories such as . . . such as . . . a normal goods projection map and the globe. It also has different features. I like it. It's pretty good.
- Q-46: *Okay. Is there anything you don't like about it?*  
A-46: Umm. Well, my 386 buffer is sometimes . . . it sometimes can't get through it and I have to run it a few times.
- Q-47: *Okay, okay. Now, do you think that "Dune" would be of value to you in learning science?*  
A-47: Umm, probably not.
- Q-48: *Why not?*  
A-48: Well, it's mostly just a fantasy game.
- Q-49: *Okay. Would you want to teach someone else how to play "Dune"?*  
A-49: Yes.
- Q-50: *Why?*  
A-50: Because I consider it a very good game.
- Q-51: *Now, do you think you could teach someone?*  
A-51: Yes.
- Q-52: *Why?*  
A-52: Because I've played it a lot and I know how to work it.
- Q-53: *Of all the stuff we've talked about computers so far, is there anything we haven't talked about that you want to mention?*  
A-53: I'm pretty good with the keyboard.
- Q-54: *Oh yeah?*  
A-54: Umm Hmmm.
- Q-55: *How do you know that?*  
A-55: Because I've typed plays. I've written things and I went through the entire Microsoft tutorial (chuckle).
- Q-56: *Oh. Those tutorials are pretty big.*  
A-56: Umm Hmmm.
- Q-57: *Okay, is there anything else you want to mention?*  
A-57: Oh, nah.
- Q-58: *Okay. Well, I think we're done. I'm going to go ahead and turn this off now.*

Q-1: *All right. We're starting Interview Number 7 for today. The first thing I would like to do is give you these little pieces of paper and what I'd like to ask you to do is to see if you can form a sentence out of these. Now, you can use all of them. You don't have to. You can just use some of them, if you want, that'd be fine but the important thing is to form a sentence that you would agree with, or that you would consider ta fact or that you would consider to be true. Okay?*

Q-1: Okay. . . (long pause) . . . Okay.

Q-2: *Why don't you go ahead and just read that?*

A-2: Temperature flows into heat energy . . . and I don't think that is a good sentence.

Q-3: *Okay. Do you want to try a little longer or . . . ?*

A-3: Yeah. . . (long pause) . . . I'm kinda stuck.

Q-4: *Okay. Where do you think you're stuck at?*

A-4: It's like words that I do need in here.

Q-5: *Okay, like what?*

A-5: I need an extra "temperature".

Q-6: *You need an extra "temperature"?*

A-6: Yeah.

Q-7: *Well, I can do that.*

A-7: Do you have another "stays in"?

Q-8: *There's another "stays in". There's another "temperature".*

A-8: I cannot say this statement is true but it's a sentence. (chuckle)

Q-9: (Chuckle) *Can you read it?*

A-9: Heat energy stays in lower temperature and cold energy stays in higher temperature.

Q-10: *Okay, now why didn't you think that was true?*

A-10: Well, I think it does make sense but it doesn't make sense, and the reason why I think it does make sense is because it's a sentence; but it doesn't make sense because I really don't know somehow.

Q-11: *Okay. Well, that makes sense.*

A-11: (Chuckle)

Q-12: *Let me ask you about this word here -- temperature.*

A-12: Umm Hmmm.

Q-13: *What do you think that means?*

A-13: Temperature. It's something to measure the coldness and hotness of an object or liquid or gas or solid or whatever. It's like, yeah.

Q-14: *Okay. Go ahead. It's like what?*

A-14: Yes. I think it is. Like. . . it measures how much . . . it measures like if you're outside and the temperature is pointing to 18 degrees below zero and that's your temperature so it measures the coldness and hotness of air or cold.

Q-15: *Okay. Now, I want to look at this word here -- heat.*

A-15: Umm Hmmm.

Q-16: *What would you say about that?*

A-16: Something that is hot or produces heat like (indistinguishable). It produces heat. It keep you warm all the time (indistinguishable). It's used for a lot of things.

Q-17: *Okay. Would you say that "heat" and "temperature" are the same or different?*

A-17: Different.

Q-18: *Why would they be different?*

A-18: Because temperature measures heat or it measures coldness but it's not the same.

Q-19: *Okay, now why did you say that heat stays in?*

- A-19: It's like . . . let's see . . . if I was to have a ther . . . no, not a thermos . . . a glass of hot water. The heat would stay in that glass of water for a certain amount of time but it's the same thing with coldness though. I should have put "heat stays in" and then "cold energy stays in". . I'm kinda confused. Wouldn't you say that?
- Q-20: *I'm curious. Where does the heat go? You said it stays in for a minute and then it goes somewhere.*
- A-20: Hmm. . . I don't know. This sentence really doesn't make sense because it doesn't really have an object.
- Q-21: *Well, I was thinking . . . the little example you gave, you said you had a pitch . . . you had a cup or a glass of hot water . . .*
- A-21: Umm Hmm.
- Q-22: *And you said the heat stays in it for a while and then it goes away.*
- A-22: Right.
- Q-23: *Where does it go?*
- A-23: It evaporates.
- Q-24: *Okay. The heat evaporates.*
- A-24: Right.
- Q-25: *Okay. Which means?*
- A-25: It's not gone but it's there but it's in a different form.
- Q-26: *Okay, what is that new form?*
- A-26: It's not condensation. It's the opposite but . . . it's the opposite of condensation that's in the air. Like if I had a glass of water. I'm using a lot of examples. If I had a glass of water and I left it there for like a week, it would be gone but it's not gone. It would be gone out of the liquid form but is in the air somewhere without reach, so that's what it means.
- Q-27: *Okay. I'm just going to have you look at one other term over here and that's this one -- heat energy. Does that mean anything to you?*
- A-27: No. It probably. . . I've heard it before but I really don't understand. I haven't learned much about it, so.
- Q-28: *Okay. Okay, great. Well, unless you want to play with these more (chuckle). . .*
- A-28: (chuckle)
- Q-29: *. . . I'm going to close them. What I'd like to do is I'd like to go on to another question.*
- A-29: Umm Hmm.
- Q-30: *And for this question, all I want to do is I want to name three different kinds of materials. And what I'd like for you to do is to tell me when I name the material if you would use it to keep something hot, to keep something cold, or to do both or to do neither, okay? The first material is aluminum foil.***
- A-30: Both.
- Q-31: *Okay, why would you say that?*
- A-31: Well, I think it's like . . . it's like . . . installation (insulation?). If I wanted to have a hot sandwich, the aluminum foil would keep the heat inside in between the aluminum and the sandwich. And if I were to have a pop can . . . a frozen pop can full of pop, it would keep the coldness between the aluminum foil. So, it would stay cold for a while.
- Q-32: *Why do you think aluminum foil does that?*
- A-32: I guess it's because of some sort of metal. Yeah, because if I were to try to do that with plastic, I don't think it will do that unless it is some sort of special plastic (indistinguishable).
- Q-33: *Okay. Next material -- wool.*
- A-33: Wool. To keep you warm.
- Q-34: *Okay. Is there something . . . do you have another example of something that would {indistinguishable}*
- A-34: (chuckle) Sheep . . . a lamb . . . a sheep. It's like fur. Fur keeps an animal warm in the

wintertime and if they don't have it, then they'll be cold. So, the sheep. . . I guess the farmer uses sheep as an example so that when they shear the sheep and then uses the wool to heat the farmer with . . . yeah.

Q-35: *Okay, would you ever use wool to keep something cold?*

A-35: No.

Q-36: *No, why not?*

A-36: It just doesn't sound like something that would keep you cold. or keep something cold.

Q-37: *Okay. Next material -- Styrofoam.*

A-37: Styrofoam. I can't answer that question 'cause I don't have a lot to say about Styrofoam but I could answer a question if some certain Styrofoam keep it hot or cold, so, yeah, it's both.

Q-38: *Okay, what's bothersome about Styrofoam?*

A-38: Because I really don't use Styrofoam because I'm against it 'cause it pollutes the air and stuff like that.

Q-39: *Okay. That's okay. But you said you could use it for, even though you wouldn't use it, somebody could use it (chuckle) . . .*

A-39: (chuckle)

Q-40: *Could you tell me again. Is there anything . . . you said the aluminum foil could be used to keep something hot. Wool could be used to keep something hot. Styrofoam could be used to keep something hot. Is there something all three of them have in common of how to keep things hot?*

A-40: Wool is like something that is suffocating, like it sucks up air and sucks up heat. So does aluminum foil and sometimes Styrofoam, depending on what kind of Styrofoam it is. So, they probably do have something in common but what, I really don't know. Is it some kind of chemical or something? I'm not sure but they do store heat, so they all have something in common.

Q-41: *Okay, let's talk about computers, okay? Do you use computers a lot?*

A-41: Yes.

Q-42: *Yes? Okay. Think about all of the different computer software that you use - all the different programs - and tell me if you can which one you would call your favorite.*

A-42: What program?

Q-43: *Umm Hmmm.*

A-43: I'd say *Claris Works*.

Q-44: *"Claris Works"? I have a scale here and I was wondering if you could just tell me . . . pick out which one of these would best describe what you think of "Claris Works"?*

A-44: The first one.

Q-45: *Okay, could you read that?*

A-45: By far the best I've used.

Q-46: *Okay. Why would you say that "Claris Works" is by far the best you've used?*

A-46: I think it's the most modern because I tried learning *The Writing Center* and I've tried a lot of different things but I like *Claris Works* because it's more easier to use and once you understand it, then you can take it to the furthest extent, say like if I was doing a report, if I had a choice between *Claris Works* and *The Writing Center*, I would choose *Claris Works* because it has better graphics and it's kind of neat to use.

Q-47: *Okay. Do you consider "Claris Works" to be hard to use, easy to use. . . ?*

A-47: It's easy to use.

Q-48: *Easy? Okay. Why is it easy to use?*

A-48: Because if you were in *The Writing Center* and you wanted a certain font, you have to go up to "Edit" and then go to "Find" and all this other stuff but if you were to use *Claris Works*, "Font" would already be there on the menu bar. It would be right there and some people don't really know how to get to "Font" in *The Writing Center* and you have to show them step by step and then they might forget again but if you were to use *Claris Works*, it



would be right there and you can find the font you want to use and it would be easy.  
(CHANGE TO TAPE 7)

Q-49: *So, you were telling me what you liked about . . . why you thought "Claris Works" was easy to use. . .*

A-49: Right.

Q-50: *Is there anything about "Claris Works" you don't like?*

A-50: Not really.

Q-51: *Okay. Now, I'm curious . . . do you think "Claris Works" would be of value to you in learning science?*

A-51: . . . (short pause) . . . Umm. Nah. I don't think so.

Q-52: *Why not?*

A-52: Yes, for projects maybe but not for learning science because I don't think that's a program that you'll learn science because you won't be taught science. Like, *Claris Works* is a writing program.

Q-53: *Umm Hmmm.*

A-53: It's usually typing and used for projects and stuff like that but not for science.

Q-54: *What kind of project do you think it would be used for?*

A-54: For laying out . . . laying out the . . . your science . . . if I had a science project, I would use *Claris Works* to have like a format, saying, for instance, on how I would use *Claris Works* to write down everything. I could use like a journal for *Claris Works* but in *The Writing Center*, I would have to go all the way. . . I would have to choose different fonts and all the other stuff but I do think that *Claris Works* would be better for science projects but not to learn about science. That'd be totally different.

Q-55: *Okay. Would you want to teach someone else how to use "Claris Works"?*

A-55: Sure.

Q-56: *Why?*

A-56: It's easy to use and if someone taught me how to use it then I would want to give back to another person so I would feel good about myself.

Q-57: *So you think "you" could teach it?*

A-57: Right.

Q-58: *And you think it would be good for them to learn it?*

A-58: Right.

Q-59: *Okay. There's one thing I meant to ask you earlier and that is, did you like "Claris Works" from the first time you used it or did it take a while to grow on you?*

A-59: Yes. This is like . . . this year was the first time I used *Claris Works* and I've tried different other programs that were like . . . ugh . . . dull. I like *Claris Works* better than I like any other typing program.

Q-60: *Okay, so did you like it right away or did it take a while to get used to it . . . to like it?*

A-60: Well, it did take me a while because I tried different programs. I didn't want to just stay in one thing, so it did take me a while before I went back to *Claris Works* and I found out I liked *Claris Works* better than I liked anything else.

Q-61: *Now, of all the stuff we've talked about computers so far, is there anything that you want to add to any of that?*

A-61: I'd have to say if I were to have children . . . it's totally off . . . it's not off the subject but it is off . . . if I were to have children that were interested in computers and trying out computers and stuff like that, I'd pick *Kid Pix* because it's easy to use and you have different things like coloring pictures when you can take the paint bucket and color certain parts and stuff like that and you can make your own design and put together a story book and stuff like that. I'd choose *Kid Pix*.

Q-62: *Umm. Okay. I'll keep that in mind. Anything else you want to say?*

A-62: No.

Q-63: *Then I think we're done and I'm going to shut this off.*

- Q-1: *All right. This is the last interview, Day 4, and what I'm going to do, to start with, . . . I'm going to put out these words here and what I was wondering if you could do . . . is I was wondering if you could look at these words and see if you could put together a sentence using them. Now, you don't have to use all of them but you can if you want to. You can use some of them. What I'm really wanting you to do is try to put together a sentence that you would agree with, or that you would consider to be a fact, or something that you think is true. Okay?*
- A-1: . . . (long pause) . . . I'm finished now. Let me just finish this one.
- Q-2: *Okay. That's okay. Why don't you go ahead and read what you've got there.*
- A-2: Heat energy stays in heat and cold energy stays in cold.
- Q-3: *Okay. So you actually wrote two of them?*
- A-3: Yeah.
- Q-4: *Let's . . . I'm just going to ask you about some of these words that you used. Could you tell me what you think "heat" is right here?*
- A-4: Heat is like warmth. Heat is something that's warm.
- Q-5: *Okay. Umm Hmmm.*
- A-5: And cold is something that's cold . . . I think
- Q-6: *Okay. What about this word here -- heat energy?*
- A-6: I really have . . . maybe the energy that comes out of the heat, or what's. . . (sigh)
- Q-7: *Okay, the energy that comes out of the heat. Do you think that "heat energy" and "heat" are the same or do you think they're different?*
- A-7: I think they have something to do with each other but they're different.
- Q-8: *Okay, how would they be different?*
- A-8: Heat is just like something and the energy is part of heat, I guess. It is what heat does.
- Q-9: *Okay. Now, what about this word here -- temperature? Would you consider "temperature" and "heat" to be the same or different?*
- A-9: Different.
- Q-10: *Okay, why would you say that?*
- A-10: Well, temperature is . . . you know you have like cold temperature or hot temperature and heat is just like a kind of temperature, like what it could be.
- Q-11: *What it could be. Okay. when you said that heat energy stays in heat . . . what did you mean when you said "stays in"?*
- A-11: Well, now that I think about it, I think it should be "flows out of heat".
- Q-12: *Okay.*
- A-12: Like if you have a heater or something, the energy is . . . flows out of the heater. That's heat energy.
- Q-13: *Okay . . . do you want to change that one too?*
- A-13: Yeah.
- Q-14: *I've got another "flows out of" if you want and I can get that for you but let me ask you this. What is it that flows out again?*
- A-14: The heat energy . . . like the energy.
- Q-15: *Okay. Now, why . . . how does it flow?*
- A-15: Like when the heat is being pushed out of a heater or something, the energy just like flows out. It just comes out.
- Q-16: *Okay. I'm just saying this for the tape. You're making this motion with your hands. What kind of motion are you making with your hands?*
- A-16: An outward motion.
- Q-17: *Okay. Now, why did you decide to change from "stays in" to "flows out", could you say*

*that one more time?*

A-17: 'Cause if I think about it, heat energy wouldn't probably stay in heat, it would, you know, come out of it . . . it's energy . . .

Q-18: *Okay, where would it go?*

A-18: I think, around, about this . . . wherever it has room to go.

Q-19: *Okay. And where would it come from, again?*

A-19: The main thing where the heat is coming from, like if it was a heater, it would come out of the heater or something. If it was a stove, it'd come off of the stove.

Q-20: *Okay.*

A-20: Like heat energy would come out of the sun to heat up the earth.

Q-21: *Okay. Okay. Good. I'm going to put these away now and what I'd like to do is ask you another question.*

**Q-22: *What I'm going to do is, I'm going to name a material and what I'd like for you to do is tell me if you would use it for keeping something hot, for keeping something cold, for doing both, or doing neither. Okay? The first material is aluminum foil.***

A-22: Probably to keep . . . probably both.

Q-23: *Okay. Why would you say that?*

A-23: 'Cause it just like packs in. It keeps the cold in or it keeps the heat in.

Q-24: *Packs it in.*

A-24: It like holds it in.

Q-25: *Holds it in? Okay. So, you'd use it for both. Can you think of an example of using aluminum foil to do that?*

A-25: Like if you had a can of pop or something and you wanted to keep it cold, you would, you know, put aluminum foil in there so the cold couldn't come out. Then, if you had a hot sandwich or something, you know, you could fold it up in there and keep the heat in.

Q-26: *Okay. Okay. I'll name another material now, okay -- wool.*

A-26: Probably to keep something warm.

Q-27: *To keep something warm. Okay. Now, why would you say that?*

A-27: Probably because . . . it's like . . . expected. If you got cold or something, you know, you could wrap up in it and it would keep you warm.

Q-28: *Okay. how do you think wool keeps something warm?*

A-28: If you . . . like if you have your body heat, it holds it in.

Q-29: *Okay. Would you ever use wool for keeping something cold?*

A-29: No.

Q-30: *No? Why not?*

A-30: 'Cause it doesn't seem like it would keep it cold.

Q-31: *Okay. Okay. I'm going to name one more material, now -- Styrofoam.*

A-31: Probably neither.

Q-32: *Okay. Why would you say that?*

A-32: 'Cause it doesn't . . . when it keeps something cool, it just keep it at the same temperature probably or I don't think it would keep it warm either.

Q-33: *Okay. Can you think of something where . . . a case where Styrofoam doesn't really do the job?*

A-33: Well, if you had a cup of hot chocolate and you went outside and cold air hit it, Styrofoam wouldn't like keep it warm and you . . .

Q-34: *Go ahead.*

A-34: If you had like a cup of cold water and you went outside and it was warm outside, it would still get warm when the air get to it.

Q-35: *Okay. Okay.*

**Q-36: *Let's talk about computers. Do you use computers a lot?***

A-36: Yeah, I have a computer at home.

- Q-37: *Do you? Okay. Okay. I'd like for you to think about all of the different computer software that you've used, okay? And tell me what you would consider your favorite program to be?*
- A-37: Even games and stuff?
- Q-38: *(cough) . . . Excuse me. Yes, anything, anything at all.*
- A-38: I like *Kid Pix* because you can . . .
- Q-39: "*Kid Pix*".
- A-39: Yeah, you can draw or write anything on there.
- Q-40: *Okay, because you can write or draw anything?*
- A-40: And you can get pictures and pretty much anything.
- Q-41: *Okay. Now, I'm going to show you a scale and what I'd like for you to do is tell me where you would . . . which one of these would best describe what you think of "*Kid Pix*".*
- A-41: That one.
- Q-42: *This one? Could you read that one?*
- A-42: I picked this as the best but I did think about other ones.
- Q-43: *Okay. Now, tell me again why you thought "*Kid Pix*" would be your favorite?*
- A-43: Because you can draw and you can write. If you need to write a story or something, you can put pictures and letters on the same page without going to a different software.
- Q-44: *Okay. Did you like "*Kid Pix*" from the first time you tried it or did it take a while for it to grow on you?*
- A-44: From the first time I tried it.
- Q-45: *Okay. What things do you like about using it?*
- A-45: You can either draw by yourself, you know, if you like free-handed drawing or you can use stamps that's already been drawn and you can use different colors and change colors on the pictures and stuff.
- Q-46: *Okay. Is there anything that you don't like about "*Kid Pix*"?*
- A-46: Sometimes, yeah, because it's hard when you use the mouse to draw with the pencil. It's like from here to there (slight chuckle).
- Q-47: *Okay.*
- A-47: It goes all over.
- Q-48: *Okay. All right. Do you think . . . consider "*Kid Pix*" hard to use or easy to use or in . . . how do you . . . ?*
- A-48: Probably easy but it's sorta confusing ta . . . you have to learn about all the different things you can do and practice on it before you really remember that you can do things.
- Q-49: *Okay. Now, do you think this program, "*Kid Pix*", would be of value to you in learning science?*
- A-49: No.
- Q-50: *No, why not?*
- A-50: 'Cause there's not really science on there. All it is is drawing or writing and {indistinguishable} . . .
- Q-51: *Okay. Would you want to teach someone else how to use this program -- how to use "*Kid Pix*"?*
- A-51: Yeah.
- Q-52: *Yeah? Why?*
- A-52: Because it's fun and I'd like other people to learn how to do it too.
- Q-53: *Okay. Do you think you could teach them?*
- A-53: Yes.
- Q-54: *Why do you think you could teach them?*
- A-54: Because I've used it for a while and I know a lot of things about it.
- Q-55: *Okay. Now, of all the things we've talked about computers so far, is there anything we haven't talked about that you just want to mention?*
- A-55: Besides the other programs that I like -- like science programs?
- Q-56: *Sure, you could do that.*

- A-56: I like science programs. You know, you can . . . there's some other programs and then . . . you know programs about health and everything that I've used before. I like them too.
- Q-57: *Why do you like them?*
- A-57: Because it's learning and it's fun and it's not just boring stuff.
- Q-58: *What is it about the program that makes it fun? Or is it the material you're learning? Which is it that's fun?*
- A-58: It's fun because it's not . . . you don't just read and learn. You know, you can do different stuff and learn about different stuff, you know, and there's colored pictures and stuff and, you know, you don't just have to look at plain . . . you know, plain items like a piece of paper that you just learn off of. It's easier to learn that way.
- Q-59: *Okay. What would you consider to be boring?*
- A-59: Reading a piece of paper and answering questions about it. (chuckle)
- Q-60: (chuckle) *Okay. All right. I think that's it. I guess I'm going to go ahead and shut this off now.*

## **APPENDIX C**

This Appendix contains transcripts of the PostInterviews. The page after this one has the rubric that was used to assess the students' responses.

## Interview “Word Scramble”

Heat energy	stays in	Objects at	cold
Temperature	flows into	and	Heat
Cold energy	flows around		higher
	flows out of		lower
			same

*The phrases which demonstrate deep understanding:*

Heat energy flows out of objects at higher temperature.  
Heat energy flows into objects at lower temperature.

*The phrases which demonstrate moderate understanding:*

Heat flows out of objects at higher temperature.  
Heat flows into objects at lower temperature.  
Heat energy stays in objects at same temperature.  
Heat stays in objects at same temperature.

*Other phrases demonstrate low understanding.*

*The inability to generate a phrase is denoted as a “null” response.*

## Interview Insulating Materials

*The response which demonstrates deep understanding:*

A: Yes, Materials are equally adept because they “impede” or insulate against molecular transfer of heat energy in an equidirectional manner.

B: While all three would work to some degree, wool and styrofoam are more effective insulating materials than aluminum foil. Any situation that is a viable representation is fine.

*The response which demonstrates moderate understanding:*

A: Yes. Materials are equally adept because they provide a physical barrier to macroscopic transfer of heat energy in an equidirectional manner. May be accompanied by a desire to perform a test such as an ELabBook simulation to look for a solution.

B: All three would work to some degree. Any situation that is a viable representation is fine.

*Other phrases which demonstrate low understanding.*

A: Yes, sometimes or no. May make a blanket or specific appeal to experience.

B: Any choice that identifies one or materials as good for “just” keeping something hot or cold, rather than

both.

*An answer of “I don’t know why” or similar inability to formulate a reply is denoted as a “null” response.*

### **Computer Software (pre)**

Categorize the software into one of three choices: telecommunications, multimedia, or software tool. Email or chat would be examples of telecommunications, games would be an example of multimedia, and educational or office software would be an example of a tool.

### **Computer Software (post)**

Compare ELabBook with the software they described before. Compare each of their answers, focusing especially on like/not like/ease of use/teach others.



- Q-1: *This is Day 1. What I'm going to do is, I'm going to name a material and I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both or doing neither, okay? Aluminum foil.*
- A-1: Cold.
- Q-2: *Okay. Why would you say you'd use it for keeping something cold?*
- A-2: Aluminum foil. Like, say, pop. If you want to keep it cold, you'd put aluminum foil around it and it'd keep the coldness trapped around it so it would keep it cold.
- Q-3: *Okay. Can you describe a situation that illustrates your answer?*
- A-3: Uhh . . . (short pause) . . .
- Q-4: *Something you've seen that makes you think this way?*
- A-4: Well, my mom did it in my lunch before.
- Q-5: *Okay.*
- A-5: And it kept it cold.
- Q-6: *Did it?*
- A-6: Yeah.
- Q-7: *Okay. Uhh, I'm going to name another material now. Wool.*
- A-7: That's good for keeping things warm.
- Q-8: *Okay. And why would you say that?*
- A-8: Well, some heat escapes but some of it doesn't and it traps it just like the aluminum foil but wool covers more and it's thick.
- Q-9: *Have you seen something that can illustrate this?*
- A-9: No. I haven't seen it done before but that's what I think.
- Q-10: *Okay. And finally, Styrofoam?*
- A-10: Uhh. Keeping things cold.
- Q-11: *Okay. And why would you say that?*
- A-11: 'Cause Styrofoam is tied together but it's soft but it keeps cold things insulated.
- Q-12: *Okay. Can you think of, again, something that would illustrate this?*
- A-12: Well, no.
- Q-13: *Now, in all three of these answers that you gave, is there something common about all of them that you noticed.*
- A-13: Well, two of them are common.
- Q-14: *Okay. What is that?*
- A-14: Two of them kept things cold.
- Q-15: *Okay.*
- Q-16: *I'm going to move on to another line of questioning, okay? I have some phrases that are written on construction paper here and I'd like for you to arrange these phrases so that they make a complete sentence, not just any sentence but one that you believe to be true. So, you can use a phrase more than once. In fact, I have extras of any of these words if you want. Just ask me and I'll give them to you. Like I said, try to make a sentence out of these as long or as short as possible. You might want to use all of them or you might not want to use every word but make a sentence that makes sense to you.*
- A-16: . . . (long pause) . . . I have a sentence.
- Q-17: *Okay, is that it?*
- A-17: Ummhmm.
- Q-18: *Could you read that?*

- A-18: Heat energy flows into cold energy.
- Q-19: *Okay. Now, what's the main reason for your answer here?*
- A-19: Umm, heat does not go into heat. Heat flows in the cold energy which makes it cold. If you had a warm pack and you put a whole bunch of ice in it, it'd turn cold because heat goes into the cold.
- Q-20: *Can you tell me what you think this is -- heat energy?*
- A-20: Uhh, energy that is heated or a heat source.
- Q-21: *Okay. What about this term -- flows into? What does this idea of flow here mean to you?*
- A-21: Uhh, it changes into, flows around, or goes into.
- Q-22: *Okay. Now, when you constructed this sentence, did you have something in mind? Were you picturing something?*
- A-22: Yeah.
- Q-23: *Okay. What was it?*
- A-23: Uhh, ice and heat.
- Q-24: *Okay, what about this word, this term here -- cold energy?*
- A-24: Uhh, cold energy is just like heat energy but it's like cold but it's energy but heat flows into it. Things turn cold and start heating up.
- Q-25: *Uhh, one more question. Did you . . . did you . . . I don't know if you . . . well, never mind. What I'm going to do is, I'm going to go on to the third one because . . . the reason I changed my mind is because I don't have the right question to ask you. I'm going to put these away.*
- Q-26: ***So, let's talk about computers for a second, okay? Now, think about the ELabBook Computer Program that you used in class. Do you remember that?***
- A-26: Ummhmm.
- Q-27: ***Okay. I'm going to show you a scale and I'd like for you to rank that ELab Program on this scale. Compare it with any other computer program that you've ever used. Where would you put ELabBook on this scale?***
- A-27: Uhh, this one.
- Q-28: *Would you read that one?*
- A-28: This is the only one I've ever used.
- Q-29: *Okay. What did you think of ELab. Did you like it or not like it, or what?*
- A-29: I liked it. It was all right.
- Q-30: *Okay. What did you like about it?*
- A-30: It helps you. It tells you where to go. If you need help, you can go to "help" and it'll tell you where to go.
- Q-31: *Is there anything you liked about it?*
- A-31: It was easy.
- Q-32: *Why did you think it was easy?*
- A-32: Well, the help menu thing, it helped me so that made it easy.
- Q-33: *Okay. Uhh, were there any things that you didn't like about it?*
- A-33: It was a little long.
- Q-34: *What do you mean by long?*
- A-34: It had a lot of lists of questions and notes. It'd get you mixed up.
- Q-35: *Oh really, how did it get you mixed up?*
- A-35: Well, like one set of notes would be about something the other way and you'll think differently and it'll mix you all up and you'll put the wrong thing.
- Q-36: *How did you know you put the wrong thing down?*
- A-36: 'Cause when you go back and look at your notes, they're all messed up.
- Q-37: *Okay. Did your opinion of ELabBook change as you used it? In other words, did you think one way about it when you first started or think another way about it after a while?*

- A-37: I thought it was stupid at first.
- Q-38: *Oh really.*
- A-38: Yeah.
- Q-39: *Why did you think it was stupid?*
- A-39: I didn't know nothing about it.
- Q-40: *Oh, okay, so you didn't think it was stupid after using it a bit?*
- A-40: Right.
- Q-41: *Okay. Do you remember the simulations and the experiments? Do you remember that with ELab you could run simulations and you could also run real experiments?*
- A-41: Yeah.
- Q-42: *Did you prefer one to the other?*
- A-42: No.
- Q-43: *No? Okay. Now, do you think this program is of value to you in learning science?*
- A-43: Yeah.
- Q-44: *Why?*
- A-44: It involves heat energy as simulations, temperature and stuff.
- Q-45: *Go ahead.*
- A-45: That's about it.
- Q-46: *Uhh, would you want to teach someone else how to use this program?*
- A-46: No.
- Q-47: *No? Why not?*
- A-47: I'm not good at explaining things.
- Q-48: *Okay, so, do you think you "could" teach them then?*
- A-48: Yeah.
- Q-49: *How do you think you could do that?*
- A-49: Well, I done it before and I'd tell them the step by step and show them where to go and stuff.
- Q-50: *One final question. Do you think that ELabBook helped you to know anything about heat?*
- A-50: Yeah.
- Q-51: *Can you think of specific things?*
- A-51: Uhh, well, heat energy and cold energy, they flow together.
- Q-52: *Anything else?*
- A-52: No.
- Q-53: *Okay. Well, that's all the questions I have. I'm going to give you a chance. Is there anything that I haven't asked you that you'd like to mention -- either about heat or about using computers in class, or anything like that?*
- 
- A-53: No.
- Q-54: *Okay. That's all. I'm going to turn the tape off now. Thanks.*

- Q-1: *This is Day 1. I'm going to start by . . . I'm going to name a material and I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both, or for doing neither, okay? Aluminum foil.*
- A-1: Both.
- Q-2: *Okay, why would you say that?*
- A-2: Because I use it for keeping things cold and to heat something up sometimes.
- Q-3: *Okay. When do you use it?*
- A-3: Mostly when I have to cook something, like if you'll put some potatoes inside the oven and heat it up in the oven with aluminum foil, or you can put something in the freezer with aluminum foil to keep it cold.
- Q-4: *What made you decide to use aluminum foil for both of these?*
- A-4: I don't know. My parents mostly taught me how to do that.
- Q-5: *Okay. Did you ever ask them why they did it?*
- A-5: No.
- Q-6: *You just did it because they did it?*
- A-6: (indistinguishable)
- Q-7: *Okay. Another material -- wool.*
- A-7: Wool is for keeping something warm.
- Q-8: *Okay. Now, why would you say that?*
- A-8: Because mostly you would use wool to keep something . . . the body warm. It would do the same thing for an object.
- Q-9: *Okay. Have you ever used wool to keep something warm?*
- A-9: No. Yeah, myself.
- Q-10: *Yeah.*
- A-10: Myself.
- Q-11: *Okay, what do you have . . . like when have you used it ?*
- A-11: A wool coat.
- Q-12: *Okay. Uhh, what about Styrofoam?*
- A-12: Styrofoam? Neither.
- Q-13: *Neither? Why not?*
- A-13: I guess, I don't think it'd be a good thing to keep something warm or cold. It would keep something safe but not something warm or cold.
- Q-14: *What is the difference between keeping something safe and keeping it warm or cold?*
- A-14: Well, if you want to keep something safe, you have to like cushion it. Styrofoam is mostly used to cushion something to keep it stable so that it won't break or hurt. It's not used to keep something warm or cold.
- Q-15: *Okay. Do you have something in mind that you're thinking of when you tell me this? An example?*
- A-15: Yes, my TV.
- Q-16: *Ummhmm.*
- A-16: It came with Styrofoam insulation so I would say it was to keep it safe.
- Q-17: *Okay. Okay.*
- Q-18: *The next thing I have is . . . I have some phrases (excuse me) I have some phrases over here that are written on this construction paper and what I'd like for you to do is to try and arrange these phrases to make some kind of a sentence that makes sense to you. Now, you might want to use all of them or you might just want to use some of*

*them but it's very important, of course, that you make some thing that make sense to you, something that you believe is true. Go ahead and take your time.*

A-18: (long pause) . . . Can I add words?

Q-19: *Sure, just tell me which words you want.*

A-19: (no response)

Q-20: *Is there any particular word you want? If you do, just say . . .*

A-20: "and".

Q-21: *Another "and"? Okay. Yes, I have extra words . . . Here's an extra "and".*

A-21: (long pause) . . . I've got this right here. I just want to use "object" by itself.

Q-22: *Okay.*

A-22: All right. Let's see. Cold and heat energy flows out of and flows into objects.

Q-23: *Okay, could you tell me the main reason you gave that?*

A-23: Okay, because if we have an empty container, you can use it equal play. Let's say you have it into a freezer, mostly cold energy is going into that container from into it and out, just like going in and making particles, ice particles, and coming out again. It also goes around it, making it cold. The same way if you had like a cup outside, it would make it active. The hot air, say hot energy, is making the cup warm and it's going around and into that cup.

Q-24: *Do you have something in mind when . . . I mean, when you talked about some of these objects, have you seen something that kind of makes you think about this?*

A-24: Yes.

Q-25: *What would that be?*

A-25: A freezer, a container. You gotta get a container and you can see the, you could say, what's this called? Some kind of frozen, something frozen, something freezing, I'll call it freezing, comes out and goes into the cup and comes out in a freezer. So, that's what that remark means.

Q-26: *Okay. I'm going to ask you what you think some of these terms mean. This term right here -- heat energy.*

A-26: I think it means heat, hot air.

Q-27: *Okay.*

A-27: Hot air or you could say fire too.

Q-28: *Okay. What about this term here -- cold energy?*

A-28: Ice, cold air, or cold water.

Q-29: *Okay, when you talk about this idea of flowing in and flowing out, what are you thinking of when you think of flowing?*

A-29: Well, when air goes into an object, it's coming out too.

Q-30: *Ummhmm.*

A-30: Air can come out so I'm just thinking, heat energy and cold energy must also come out. When it goes into an object, it doesn't stay there, it comes out of there. Therefore, the more cold air that comes more in . . . that comes in there more . . . it just comes out, goes in, comes out. That's how you get it cold.

Q-31: *Ummhmm. Okay. One other thing I was going to ask you, do you see these two as being anything the same or do you see them as being different -- cold energy and heat energy?*

A-31: Opposites.

Q-32: *Opposites. Okay. That's it for that.*

Q-33: *I'd like to talk about computers now for a second. Do you remember that software called ELabBook that we used?*

A-33: Ummhmm.

Q-34: *Okay. I'd like for you to think about that program for a minute and I'm going to show you a scale right here. I'd like for you to rank that ELab Program on this scale and compare it to any other program that you've ever used, any other computer*

***program you've ever used.***

- A-34: . . . (long pause) . . . I don't really . . .
- Q-35: *Which one would you put it at?*
- A-35: I've had better but this ranks lower than some of my other favorites.
- Q-36: *Okay. I'm going to ask you why would you rank it that way?*
- A-36: It's not the best one . . . it's not the best program I've ever used. It's a good program to learn but it's not the best I've ever used.
- Q-37: *Okay. What is it that makes it not the best?*
- A-37: Umm. You should be able to do more things with it.
- Q-38: *Okay. Like what?*
- A-38: More graphics, maybe more animation.
- Q-39: *Do you have something . . . it's all right, go ahead. . . do you have something in mind? Did you have like specific graphics or animation in mind?*
- A-39: Oh, it could make . . . well, it could show a little bit more the coke can . . . the water going . . . the stuff going into the coke cans . . . a whole bunch of stuff . . . you could put in water if you show water going into a container. You could show animation that could say stuff . . . kids like that . . . like for the computer to talk to 'em. You could say "heat energy flows into something" or . . . you could do a whole bunch of things to make it fun. You could give other examples like more things that kids would probably . . . instead of . . . let's say, instead of paper, ordinary paper, you could do coloring paper, you know, like coloring book paper and more things like that. Maybe even cartoon characters.
- Q-40: *Kind of like cartoon characters that are part of the program, you mean?*
- A-40: Yeah.
- Q-41: *Hmmmm.*
- A-41: Like a character for each different program.
- Q-42: *Umm Hmmm.*
- A-42: Like maybe a dog with a professor hat; something like that.
- Q-43: *Hmmm. Hmmm. Okay. Now, did you have this opinion about ELabBook from the first time you started using it or did it change over the course of using it?*
- A-43: Hmmm . . . it started to change. At first, I didn't like it too much. But then, when I saw that you could use . . . I don't know, there's something 'bout variety that gets to me. I guess I saw that you could use more, like coke cans and chile and stuff and you got more variety of what you wanted to use, I decided it was a little bit more better. . . to see the different kinds of objects that you can use.
- Q-44: *Right. Okay. Do you think it was easy to use?*
- A-44: Umm. Somewhat.
- Q-45: *Could you explain more?*
- A-45: Well, some parts were kinda difficult because if you mess up on one part, you have to go all over to get it . . . you have to go all over again to fix your mistake.
- Q-46: *Hmmmm.*
- A-46: So that's how it (indistinguishable) about it.
- Q-47: *Okay. What did you think about the notes that you were asked to fill in? All those questions you were asked to answer and stuff?*
- A-47: Oh. Well, some of them was asking the same questions over and over again . . . well, somewhat the same questions. That what kinda made me mad and I had to answer. You know, it would change like a few words but basically the same question but you had to come with a whole different area.
- Q-48: *Why did that make you mad?*
- A-48: It was kinda frustrating.
- Q-49: *Why was that? Why was it frustrating?*

- A-49: Because it was like you answered the same question but you changed to different words . . . like it would say . . . it would be like . . . it says uhh "heat energy" . . . like "how . . . how . . . how does the" . . . it would say "how does the cold energy uhh goes into the container" and then it would say "how many different ways does the cold energy go into the container"? Now, shouldn't we go to a different one? It seems like we should go to a different one. If we know how it goes, of course we know the different ways that it could go into the uhh . . . into the object. It was something like that.
- Q-50: *Okay. I see what you're saying. Do you think this program is of value to you in learning science?*
- A-50: Yeah.
- Q-51: *Why?*
- A-51: Because it teaches you about the different heat and cold energies and how tempera- will go down and up in different situations.
- Q-52: *Okay. Okay. Would you want to teach someone else how to use this program?*
- A-52: No, because I think that with some people at the school would get more frustrated.
- Q-53: *Do you think you could teach if you did?*
- A-53: I probably could.
- Q-54: *Why would you say that?*
- A-54: Once you learn how to use the program, it's pretty easy.
- Q-55: *Okay. Now, I finished asking all the questions. Is there anything that I haven't asked that you just want to add or talk about?*
- A-55: No.
- Q-56: *Okay. Thanks. I guess that's it. I'm going to stop the tape now.*

- Q-1: *This is Day 1. What I'm going to do to start is I'm going to name three materials and for each one, I'd like for you to tell me if you would use it for keeping something hot, keeping something cold, for doing both, or for doing neither. Okay?*
- A-1: Okay.
- Q-2: *The first material is aluminum foil.*
- A-2: Neither.
- Q-3: *Okay. Why would you say that?*
- A-3: It's a good conductor. It conducts cold and it conducts little heat energy and it conducts large amounts of heat energy
- Q-4: *Ummhmm.*
- A-4: Very easily.
- Q-5: *Okay. So, why does that mean that you wouldn't want to use it?*
- A-5: Well, for one thing, it would make it very easy to . . . it's a very good conductor and quite simply put, it's just too good of a conductor.
- Q-6: *Ummhmm.*
- A-6: Poor conductors work better uhh to keep something insulated.
- Q-7: *Okay. Can you think of an experience or a situation that would illustrate this?*
- A-7: Uhh. When we were testing, we tested aluminum foil and Styrofoam. Styrofoam was a better conductor and aluminum foil lost most of its heat on the simulation and in real life.
- Q-8: *Umm Hmmm. Okay. I'm going to name another material now. Wool.*
- A-8: Keeping something warm.
- Q-9: *Now, why would you say that?*
- A-9: It's a good conductor but it also . . . also can retain small amounts of less and heat energy. Small amounts of heat energy can seep into . . . can go into the wool but won't keep the thing . . . Hmmm, I lost my train of thought . . . (chuckle) . . . okay . . . wool will . . . well, it worked well on the simulation.
- Q-10: *What happened on the simulation?*
- A-10: It kept stuff warm and not cold . . . and kept stuff warm when it was supposed to be kept cold and kept stuff warm when it was supposed to be warm, okay?
- Q-11: *So you saw it doing the same. . .*
- A-11: Right.
- Q-12: *Okay. I'm going to try one more material -- Styrofoam.*
- A-12: Uhh. Momentary . . . what did you just say? (chuckle)
- Q-13: *I'm going to try one more material. (chuckle)*
- A-13: Oh. (chuckle)
- Q-14: *Styrofoam.*
- A-14: Styrofoam. Good for both. It's a poor conductor and it's used in most of the thermoses that I've used my hands on.
- Q-15: *Umm Hmmm. Why does that make it good for both?*
- A-15: Well, it seems to have very small pockets of air in it and Styrofoam seems to be able to block off heat energy.
- Q-16: *Hmmm. Okay. Now, of all three of these materials you talked about something being a good conductor or a bad conductor. What does that mean to be a good or a bad conductor?*
- A-16: Well, a good conductor is something you wouldn't use to insulate. You would use it for . . . maybe to uhh . . . for a telephone line because you can transfer electrical impulses with it. A bad conductor, you wouldn't use it for electricity or anything



- like that. You would use it to insulate stuff because energy doesn't go through it as easily as a good conductor.
- Q-17: *Do you know what would make something a good or bad conductor? What makes wool or Styrofoam or aluminum foil the kind of conductor they are?*
- A-17: I think it has something to do with the atomic weight of the molecules or the spacing between the two molecules.
- Q-18: *Okay. If you want to go on, go ahead.*
- A-18: I really don't understand a lot of the . . . a lot of the thermodynamics but I do know what's a good conductor and what's a bad conductor. That's about it.
- Q-19: *Okay. How would you know . . . how do you know which is which?*
- A-19: I uhh check 'em out and find out which one is and which one isn't.
- Q-20: *Okay. Okay. That's good.*
- Q-21: *I have some phrases that I've written down on construction paper here and I'd like for you to arrange these phrases so that they make a complete sentence that you believe to be true. You can use a phrase more than once if you want to. You don't have to use every phrase to make your sentence but what's most important is that whatever you come up is something that you really think is true. (END OF SIDE A AND START OF SIDE B OF TAPE 8) . . . (short pause) . . . I can give you more phrases if you want . . . (short pause)*
- A-21: More phrases?
- Q-22: *Yeah. Which ones do you want?*
- A-22: Specifically ones that have to deal with two objects of the same temperature in this same heating room. . . Heat energy flows out of objects at higher temperature and stays in objects at . . . uhh, the?
- Q-23: *We'll pretend there is a "the" there.*
- A-23: . . . the same temperature.
- Q-24: *Okay. Can you tell me why you believe that's true?*
- A-24: Umm. It . . . well, it goes with uhh one of the thermodynamics. I don't know if its the second or first. I know that one of them is "no energy is created nor destroyed" and the other is uhh "heat energy flows . . . out of the . . . uhh . . . heat energy flows out of the objects with large heat energy and flows into objects with low heat energy". Something like that.
- Q-25: *Okay. I'm going to ask you what some of these mean to you. What does this term -- heat energy -- mean to you?*
- A-25: Uhh, basically, just the amount of energy within a object and how fast the molecules are moving around in it.
- Q-26: *Okay. What about this term here -- temperature -- you've got in here?*
- A-26: Measurement of how much heat energy is going around . . . in an object or medium.
- Q-27: *Okay and this word here -- flows ?*
- A-27: Going from one place to another through some type of channel or going all around the object.
- Q-28: *Okay. How does heat energy flow?*
- A-28: (Indistinguishable) . . . it usually flows out of the object with the higher temperature and goes into the object with the lower temperature.
- Q-29: *Okay. Now, do you have something in mind . . . can you picture something that would illustrate what you wrote here?*
- A-29: Umm. Placing a hot potato next to an ice cube. The ice cube melts and the hot potato becomes cold.
- Q-30: *Okay. All right. That's good.*
- Q-31: *Now, what I'd like to do is talk a little bit about computers, okay? And what I'd like*

*to do is . . . I'd like to . . . do you remember the ELab Program that we used?*

- A-31: Ummhmm.
- Q-32: *I'm going to show you a scale and I would like for you to pick where on this scale you would rank ELabBook against any other computer program you've ever used. You can just tell me. You don't have to write it down.*
- A-32: Uhh. It was okay but I've never used anything I really liked, except for the computer game programs (chuckle).
- Q-33: *Well, you can compare ELabBook to the computer game programs.*
- A-33: Okay. Considering that, it socked.
- Q-34: *Okay. Now, can you tell me why you would say that?*
- A-34: Well, the game programs are a lot more fun but against constructive systems, it was okay. It was medium. It was okay. It was done pretty good. Very easy to run with but it would have been better if they'd used something that wasn't . . . a computer that wasn't created in the 70's.
- Q-35: (chuckle) *Okay. What I'm curious about is if there's things about the way the program was designed that when you used it that you liked or didn't like.*
- A-35: Umm. For one thing, it took so long for the program to gather all of its materials. Maybe, if you could get a computer that was a bit more powerful.
- Q-36: *Okay. What about the way the program operated? Was there anything you liked or didn't like about that?*
- A-36: The program went fine. It run . . . ran pretty good, about as good as anything I've seen and that's the only thing I've seen about what the program was like.
- Q-37: *Okay. Did you think it was easy to use or difficult?*
- A-37: Umm. Middle of the road.
- Q-38: *Did you change how you felt about it from the start to the finish?*
- A-38: Well, I figured it would be an easy program and then I changed my thought into an adequate program.
- Q-39: *What made you change your thought?*
- A-39: Well, it takes a long time for the program to gather all of its graphics and the protocols that you had to go through were so long that maybe if you blended them all together into one part of notebooks where you did one part instead of just a bunch of tabs and just where you do all the graphing systems together instead of doing them separately.
- Q-40: *Okay. I'm going to ask you this. What did you think about the notes that you were asked to fill in?*
- A-40: They were easy enough.
- Q-41: *Okay. Why do you think they were easy enough?*
- A-41: Well, they were . . . good . . . they were phrased good. They were simple because all we had to do was fill in the rest of the sentence or answer a question or phase in our thoughts. It was pretty well prepared for us. We really didn't have to do anything that the computer didn't virtually do all by itself.
- Q-42: *Hmmm. Okay. Do you think this computer program was of value to you in learning science?*
- A-42: Yeah. Ummhmm.
- Q-43: *How so?*
- A-43: It taught me a lot about thermodynamics.
- Q-44: *Oh really? Like what?*
- A-44: Well, for one thing, I know how to keep my salami on rye cold on a hot July day.
- Q-45: *And how would that be?*
- A-45: Well, I can just place it in the cooler and I know how the cooler works now.
- Q-46: *Okay. Would you want to teach someone else how to use this program?*
- A-46: Yeah. Ummhmm.
- Q-47: *Why?*

- A-47: Well, I guess it would help he or she learn more about thermodynamics.
- Q-48: *Okay and do you think you could teach them?*
- A-48: Ummhmm. Yeah.
- Q-49: *Okay. Now, that's all the questions I've got. Is there anything I haven't asked that you want to add about the software or about anything else?*
- A-49: It was slow. It was adequate but it could have been easier if you'd clumped the sections together into maybe three or four different parts instead of just slipping them into maybe seven or eight parts. And . . . uhh maybe if we got another trust fund to get the science lab computers to be a bit more fast.
- Q-50: *Okay. All right. That's it. I'm going to go ahead and shut this off.*

- Q-1: *This is Day 1. To start with, I have some phrases that are written down on construction paper and I'd like for you to arrange these phrases and somehow try to create a sentence out of them, a sentence that you would believe to be true or that you would agree with. You don't have to use every phrase, you can if you want to, but what's important is that you make something that you really believe to be true.*
- A-1: Okay.
- Q-2: *Go ahead and take your time.*
- A-2: (Transcription Note: Long pause with background sounds like person is thinking out loud)
- Q-3: *You can go ahead and think out loud if you want.*
- A-3: Okay. I'm trying to think. Cold energy turns . . . can turn into heat because . . . 'cause if it like gets cold and it stays out for a while it can like turn hot, right?
- Q-4: *Okay. Do you have something that you think is a sentence here or are you just asking?*
- A-4: Cold turns . . . cold energy flows into heat energy and . . . I don't know.
- Q-5: *If you want to just start with these three and just add something just off your head. that would be okay. You were sort of doing that a minute ago.*
- A-5: Cold energy . . . it like . . . it can flow into . . . it can like turn into heat because it's like cold and if it stay out for hours it can get the wrong gas.
- Q-6: *Okay, let me ask you. What would you call this term right here -- cold energy? What does that mean to you?*
- A-6: Umm . . . it's like energy from cold things like ice cubes. It gives off energy to like . . . it gives off cold energy like if you put an ice cube into like one glass of pop then the cold energy from the ice cube goes into the pop and makes the pop cold.
- Q-7: *Okay. Now, what about this term here -- heat energy?*
- A-7: You put something hot into like . . . like if you take like a real cold glass and then pour something hot into it, it'll make the glass warm.
- Q-8: *Okay. What about this word here -- flows. What does that mean to you -- that energy flows?*
- A-8: It like moves . . . like at a rapid pace . . . it moves . . . like if you look at flowing water and the bubbles and how it moves . . . and like, it just moves, I guess.
- Q-9: *Okay. Now, you had . . . you had a couple of pictures in your head when you were talking about this. You had the ice cube and the pop and then . . . did you . . . are these things that . . . were you thinking about these things when you were constructing this sentence?*
- A-9: Uhh Huh.
- Q-10: *You have actually seen this happen then. Okay. What I'm going to do then . . . I'm going to go ahead and take these out and . . .*
- Q-11: *. . . I'm going to ask you a second question. What I'm going to ask you is this. Do containers or wraps that help keep hot objects hot also keep cold objects cold?*
- A-11: Uhh . . . yeah 'cause like if you like have like something warm with you and you want to keep it warm, you can put like tin foil to keep it warmer or like if you got . . . like if you have something cold, tin foil will keep it cold longer. Styrofoam keeps the same thing just like tin foil, if it's hot, it'll keep it hot and if it's cold, it'll keep it cold.
- Q-12: *Okay. Do you think you can make that general? Can I say that for any material?*

- Or are just specific . . . ?*
- A-12: Just for some.
- Q-13: *Which ones can you give examples of that you can say that for?*
- A-13: Styrofoam can . . . and I don't know . . . I don't think tin foil like can like when we tried . . . when we did the experiments. The tin foil really didn't keep it very much warmer. . . and . . . I can't think of what else besides Styrofoam.
- Q-14: *Okay. What is it about these objects that keep things hot and keep things cold?*
- A-14: Just . . .
- Q-15: *Like what is it about Styrofoam for instance?*
- A-15: It's just . . . I don't know . . . I guess it just makes things warm or cold.
- Q-16: *Okay. Can you think of a container or wrap that wouldn't keep things hot and also keep thing cold?*
- A-16: That wouldn't do both?
- Q-17: *Right, that wouldn't do both.*
- A-17: Like ceramic wouldn't help. It helps it like keep fresh . . . it'll like keep it fresh but it wouldn't help the heat at all.
- Q-18: *Do you have something in mind when we were talking about the Styrofoam and the tin foil -- again, were you picturing something? What was that?*
- A-18: Like when you . . . like when you sometime go over to one of the ice cream places, you can get like something cold to drink and they give it to you in Styrofoam cups and it keeps it cold for a while; and like in the wintertime, you go over to some place like a hot dog place and if you're outside, you put it in like a Styrofoam cup or something and it keeps it warm.
- Q-19: *Okay.*
- Q-20: ***Okay, let's go ahead and talk about computers now. I'd like for you to think about that ELabBook Program that we used. Do you remember that? I'm going to show you a scale here and I'd like for you to rank ELabBook on this scale in comparison to any other computer program you've ever used.***
- A-20: Probably this one because I've never really ever done anything like science like that and like I didn't know stuff like that. It was interesting to see how the result came out in the computer and then when we did it, like I had something in real life of how it works, of course.
- Q-21: *Could you read that one you picked?*
- A-21: I picked "This is the best but I did think about other ones".
- Q-22: *Okay. Were there any things that you . . . what did you like about using ELabBook?*
- A-22: It was interesting to see how . . . like the results . . . like how when we picked . . . we had to pick whatever, you know, we wanted to do and how the results came out; and then when we did the experiments how they were kind of alike; and then it showed in, you know, in real life how temperatures rise and they fell and everything.
- Q-23: *Okay. Was there any other thing you liked about it?*
- A-23: Uhh Uhh.
- Q-24: *Okay. Were there any things that you did not like about it?*
- A-24: Uhh, it kind of took a long time. That's probably about it.
- Q-25: *In what way did it take a long time?*
- A-25: Well, like when you were doing . . . like when you did the simulation, it kind of took a while for the thoughts to all come in and you had to answer a lot of questions.
- Q-26: *Ummhmm. What did you think about all those notes that you were asked to fill in?*
- A-26: It probably helped, you know, . . . like if they didn't ask the questions, you probably wouldn't have understood what you did as much so they were probably good to have there.
- Q-27: *Do you think you understood what was happening?*

- A-27: Yeah.
- Q-28: *So you think the notes helped you then. Do you think this program was of value to you in learning science?*
- A-28: Yeah 'cause I needed to . . . I never really understood heat energy and cold energy and how things like that worked and how the temperatures fall and rise and how some things kept it warm and how some things didn't.
- Q-29: *Umm.*
- A-29: So it helped.
- Q-30: *Can you give a specific example of how you thought this thing helped you?*
- A-30: Like in the beginning, I thought like tin foil would keep . . . help keep things warmer for a long time but like by doing the experiments, it really didn't help very much.
- Q-31: *Okay. Now, would you want to teach someone else how to use this program?*
- A-31: I could teach 'em.
- Q-32: *Do you think you'd be good to teach them. I mean, do you think you'd like to do it?*
- A-32: Sure. I would do it.
- Q-33: *Why do you think it would be worthwhile?*
- A-33: Well, like I didn't understand it and there are probably other people who don't understand everything, I guess.
- Q-34: *Okay. Did your opinion of ELabBook change when you first started using it to after a while?*
- A-34: Yeah. At first I thought it was kind of stupid and it was boring but then it started getting interesting when I figured out how to do it all and got it right.
- Q-35: *What made you think it was stupid and boring at first?*
- A-35: Because it was taking a long time and I had to answer a lot of questions and you always had to explain your answer and I go (indistinguishable).
- Q-36: (chuckle) *And what made it more . . . less stupid and less boring after a while?*
- A-36: Well, like after a while, I started paying more attention to it and figured out, you know, how to do it but like it has to take time to do it and then I figured out what I was doing with it.
- Q-37: *That's probably all for the questions I've got. Is there anything that you want to just comment on now?*
- A-37: No, I don't.
- Q-38: *Okay. Then I think we're all done. I'm going to shut this off.*

- Q-1: *This is Day 1. What I'd like to do to start is . . . I have these phrases here on construction paper and what I'd like to do is give these to you and ask you to make a sentence that you would agree with. Now, you don't have to use every phrase but you can, if you want to. What's very important though is that whatever sentence you make is something that you agree with and makes sense to you. Go ahead and take your time.*
- A-1: . . . (long pause) . . . I can't make sense.
- Q-2: *I can give you some more if you want . . . if you need some more phrases.*
- A-2: (plane sound drowns out sound) . . . electrical . . . and temperature and (indistinguishable). I need an "and" here and "temperature".
- Q-3: *Okay. There's a "temperature" and there's an "and". Do you want to read all that?*
- A-3: Cold energy flows out of objects at lower temperatures and heat energy flows around and flows into cold temperatures.
- Q-4: *Okay. Now, can you tell me what it is about that , that you find . . . that you agree with or why you agree with that?*
- A-4: Cold energy flows out of something that is cold. If there is a heat temperature, it'll go around and into the cold energy to make it hot.
- Q-5: *Okay. Is there any particular reason you picked this? Did you have something in mind when you made this out?*
- A-5: You know, we were doing that experiment where . . . on hot and cold energy . . . and we were trying to keep the heat out of it. If we didn't use the . . . the insulator we used, the heat would have come in and the colder temperature would have rose up and the heat energy would flow around and into the cold energy source.
- Q-6: *Okay. Now, I'm going to ask you if you could tell me what some of these words mean. This word right here -- cold energy. Can you tell me what that word means?*
- A-6: Energy source sounds like somewhat like . . . like going around . . . like energy coming off of something or going around an area and it would just be cold, so cold air coming out of something and flowing around like a base area.
- Q-7: *Okay. What about this one right here -- heat energy?*
- A-7: It's the same thing with heat but it's just heat that's come out of a base the same.
- Q-8: *Okay, how about this word here -- temperature? You've got that a couple of times here.*
- A-8: Temperature is like the degree of the heat or coldness of hotter or colder.
- Q-9: *Okay. Last one. This idea of flow -- (sounds like the rap of a pointer on a table) right here, and right here and right here ?*
- A-9: Like moving along with the air, as the wind blows or something. Like the cold air flows . . . like cold air ordinarily flows . . . that it's flowing out of the energy source and flowing along. The heat energy is doing the same thing. It's going towards the cold energy and they meet and it starts to take the cold temperature away.
- Q-10: *Okay. All right. I'm going to put these away now and . . .*
- Q-11: *. . . I'm going to ask you another question. I'd like to ask you this. Do containers or wraps that help keep hot objects hot also keep cold objects cold?*
- A-11: Sometimes . . . it depends on what kind of insulator. . . seems like . . . you know, a lot of people say . . . sometimes they'll say it keeps it cold. Someone else says it keeps it hot. Somebody else says it'll keep it cold and hot.

- Q-12: *Hmmm. Can you think of examples for those?*
- A-12: . . . (short pause) . . . well, like people put their pops in saran wrap to keep it cold and I know that people put like . . . some 'ill make something in a pan that'll be hot and they'll put it over the top of it to cover it to keep the heat enjur . . . energy inside it.
- Q-13: *Okay. Can you think of . . . you said sometimes it does and sometimes it doesn't. What would make the difference between one that would work for both and one that wouldn't work for both.*
- A-13: By the insulator.
- Q-14: *How would you be able to tell whether something was a good insulator or not?*
- A-14: You'd have to test it, I guess.
- Q-15: *How would you do that?*
- A-15: Sort of we could do what we did in class and put an insulator on and put it in heat and put it in cold water and see what the temperature does and switch around putting hot water . . . some cold and hot water and see if it holds the same way.
- Q-16: *Can you think of specific wraps or containers that you know would work for both?*
- A-16: I feel like Styrofoam. There's a lot of things there in that Styrofoam that I would say would keep in heat and cold.
- Q-17: *Can you think of one that wouldn't work for both?*
- A-17: . . . (long pause) . . .
- Q-18: *Not really?*
- A-18: I'm trying to think of what I used to cover all the stuff . . . uhh, like . . . I can't really think of anything.
- Q-19: *Okay.*
- Q-20: *Let's talk about computers now. Think of the ELabBook Computer Program that you used in class? Do you remember that? I'm going to show you a scale here and I'd like for you to rank ELabBook on this scale in comparison to any other computer program you've ever used. (CHANGE TO TAPE 9)***
- A-20: I guess I can pick "This is the only one I've ever used" because it was . . . like what am I ranking, like well . . .
- Q-21: *If there's a rank you want to give it that's not on the scale, you can make one up if you want.*
- A-21: I thought it should have been sorta faster, the way it was taking all the time between the exercises and stuff, figuring out what it was doing.
- Q-22: *When again was it taking a lot of time?*
- A-22: Like uhh between when you would pick your . . . to show you the list and you push . . . let me see what was it . . . uhh the wrong thing, so you go to another window and pick it from there and if you got the wrong time and get to other stuff it. I feel what it was that it took a lot of time to go through to where I was supposed to be.
- Q-23: *So, where would you want to rank it? Do you want to use this one or do you want to make one up?*
- A-23: I guess I could use that one.
- Q-24: *Okay. Could you read that one?*
- A-24: This is the only one I've ever used.
- Q-25: *So, one of the things I was going to ask you is, what were some of the things you liked and didn't like about it. I guess we got to one you didn't like already. We'll keep on going. Is there anything else you really didn't like about it?*
- A-25: I didn't like all the questions (indistinguishable) . . . (chuckle) . . . Let's see, I liked . . . I'm sorry I hate to find out where everything is ranking and where to keep what cold and about what's best and . . . and what keeps the best . . . and be sure and find out so you know where . . . and be sure you can . . . what will work best . . . all the stuff you use.



- Q-26: *Are you saying you wish you could have written that in somewhere or are you saying it did help you?*
- A-26: It's like . . . I forgot now like . . . but like it would have been nice like to keep notes so I could remember what worked best with what stuff. Say like with a baked potato, to find out what would work best of all the stuff to remember to use.
- Q-27: *So, you're sorta talking about something that you could go from any experiment you were in . . . like to write down notes to compare different experiments. Is that sort of what you're saying?*
- A-27: Yeah. Sorta like an index for everyday use to find out which would be best to buy to use for . . . stuff to keep stuff cold.
- Q-28: *Okay. Now, are there some things that you liked about ELabBook?*
- A-28: The easiest part sort of . . . about all that stuff about and rewriting the questions and getting (indistinguishable) . . . I guess it was fun to find out about insulators and finding out what the (indistinguishable) and stuff is.
- Q-29: *Okay. Did your opinion of ELabBook change from the time you started to the time you finished or was it pretty much the same the whole time?*
- A-29: At the beginning, it was sort of better like I thought it was very . . . I liked it. I liked it. Then, all of a sudden, it started getting sort of boring during the last experiments.
- Q-30: *Why was that?*
- A-30: Because it was sort of like doing the same thing over and over, just the same questions and everything, just different stuff. I didn't like writing all the questions. You know, writing the same thing over and over for just different exercises and changing a few words in between.
- Q-31: *Umm Hmmm. Okay. Do you think ELab was easy to use?*
- A-31: I don't know. At the beginning, it wasn't but then it started getting easy after hearing about the stuff you gotta put in the temperatures and what times . . . the timing and stuff.
- Q-32: *Okay. And tell me more . . . what do you think about those notes that you were asked to fill out?*
- A-32: It was sort of like the main . . . the same questions over and over, just changing a couple of words in between for different experiments.
- Q-33: *Okay. Do you think this program was of value to you in learning science?*
- A-33: Yeah, for the same things like knowing insulators and things.
- Q-34: *You mentioned earlier that you . . . it was kind of fun to do that sort of thing.*
- A-34: You have to be really into it.
- Q-35: *Would you want to teach someone else how to use this program?*
- A-35: Yeah, I guess.
- Q-36: *Why?*
- A-36: So they could find out too just . . . I think they should just have more things though between the choices of what you could use before you decide what's best.
- Q-37: *Umm Hmmm.*
- A-37: Then I think it would be better if they had that . . . then it would be better to show people so then they could decide the questions and then they could click the stuff to see whatever is best to use . . . so maybe they could just pick . . . like go to . . . say like they had the food and like the wrap or whatever, and all the different wraps that tell us which is the best on whatever you use.
- Q-38: *Okay. Do you think you would be able to teach someone? Do you think you would be able to show someone how to use it?*
- A-38: I'd probably have to have a . . . some (indistinguishable) like (indistinguishable) and stuff. I probably wouldn't be able to do it like every day. I'd probably have to ask a couple of questions.
- Q-39: *Okay. Now, that's all the questions I have for you. Is there anything you just want to comment on in general about ELabBook or anything else?*

A-39: Not really.

Q-40: *Okay. I think that's it. I'm going to shut this off.*

- Q-1: *This is Day 1. To start off with, I'm going to name three materials and every time I name one of those materials, I'd like for you to tell me if you'd use it for keeping something hot, for keeping something cold, for doing both, or for doing neither. Okay. The first material is aluminum foil.*
- A-1: Hot.
- Q-2: *Now, why would you say that?*
- A-2: Because it keeps the heat stored in it, I guess.
- Q-3: *Do you have something in mind that . . . an experience or something you've seen, that tells you this is true?*
- A-3: If you are cooking something in the oven, then you put the aluminum foil on top and you turn the oven off and it'll keep the food hot.
- Q-4: *Okay. Is there a reason you wouldn't want to use aluminum foil for keeping something cold?*
- A-4: No. For both cold and hot.
- Q-5: *Okay. So you think it could do both?*
- A-5: (Inaudible)
- Q-6: *Okay. Second material is wool.*
- A-6: Both. No, wait, cold.
- Q-7: *Okay. So, you'd use wool for keeping something cold. Is there something . . . again, a situation you can think of?*
- A-7: No, but if you sit . . . if you set a pop outside and you wrap wool around it and the pop is frozen, then it'll stay cooler . . . cool . . . I guess.
- Q-8: *Okay. Again, is there something about wool that would not allow it to be used to keep something hot?*
- A-8: Because . . . if . . . it depends on what kind of wool it is or how it's made or whatever, I don't know, but air can shoot through it and make the food cool off.
- Q-9: *Okay. Now what about Styrofoam?*
- A-9: Hot and cold.
- Q-10: *Okay. So it can do both? Why would you say that?*
- A-10: Not hot and cold, just hot.
- Q-11: *Just hot. Okay. So, why would you say that?*
- A-11: Because of the Styrofoam lock(?), I don't know. I think it keeps the heat in so it locks . . . blocks the heat inside of the container or whatever you're using instead of letting all the heat go out.
- Q-12: *Okay. Again, is there something in your mind, in a situation or experience that would illustrate this?*
- A-12: No. Wait. We did the potato (indistinguishable) thing. We used Styrofoam to wrap our potato and it stayed hot longer than the other potato that was wrapped in wool.
- Q-13: *Okay. All right. Great. Next . . .*
- A-13: . . . that sentence thing (chuckle).
- Q-14: *Yes. You remember this part (chuckle).*
- Q-15: *I have some phrases that are written here on this construction paper and what I'd like for you to do is to try and construct a sentence out of this. Now, you don't have to use every phrase, although you certainly can if you want to, and the important part of this is to be sure that you construct a sentence that you agree with or that you think is true, something that makes sense to you. Okay? Go ahead and take your time.*
- A-15: Hmmm? . . . Heat . . . Umm. (Indistinguishable sounds as though talking to

self) Heat . . . higher . . . (long pause) . . . I don't have enough words.

Q-16: *Okay. I've got other phrases that aren't here if you want to use some more.*

A-16: I need "room".

Q-17: *"Room". Okay, let's just pretend that's in there now. Just leave a blank spot for it and we'll know that "room" is in there.*

A-17: Okay. How about . . . (indistinguishable sounds as if talking to self). Okay, I'm done.

Q-18: *Okay, why don't you go ahead and read it?*

A-18: Heat flows around the room.

Q-19: *Heat flows around the room. Okay. Can you tell me what it is about that sentence that you . . . ?*

A-19: It's the only one I could find.

Q-20: *Well, do you think that's true?*

A-20: Yeah.

Q-21: *Now, why do you think it's true?*

A-21: Because if you turn the heater on, then the heat comes up and flows around the room and surrounds the whole room.

Q-22: *Okay. I'm going to ask you, what do you think this word means here -- heat?*

A-22: You asked me that last time? Uhh, something that keep warm (indistinguishable), I guess.

Q-23: *Okay. Something that warms one up. What about this word here -- flows?*

A-23: Something that moves around, I guess.

Q-24: *Okay. Why would you . . . what do you think of when you think of heat flowing?*

A-24: Heat moves out from the vent to the . . . around the room.

Q-25: *Okay. I'm wondering . . . what . . . if I brought this term over here -- heat energy -- what would you think that means?*

A-25: The heat . . . the energy from the heat, I guess . . . I . . . energy from the heat warms up the room.

Q-26: *Okay. Do you see these two -- heat energy and heat as being the same or different?*

A-26: Uhh, different . . . because the heat energy, I guess, would be . . . I don't know. I guess they're the same. I don't know.

Q-27: *Okay. So you think they're the same then, pretty much the same? All right, then I'm going to go ahead and put this away then, and . . .*

Q-28: *. . . let's talk about computers now. okay. Think about the ELabBook Program that you used, do you remember that?*

A-28: Ummhmm.

Q-29: *Okay . . . I'd like . . . I'm going to show you this scale here and I'd like for you to tell me where you think that ELabBook would fit, where you would put it on this scale in comparison to all the other computer programs you've used before?*

A-29: . . . Umm . . . it was okay but there were others I really liked.

Q-30: *Okay. Can you tell me why you picked that?*

A-30: Because I didn't like it that much . . . I mean, I liked it but it wasn't better than the *The Great Solar System Rescue* or something, I don't know.

Q-31: *Okay.*

A-31: Or that one thing we did in sixth grade with the ocean (indistinguishable), I don't know. I forgot what it's called.

Q-32: *Let me ask you this. Were there some things about ELabBook that you liked?*

A-32: Uhh . . . (chuckle)

Q-33: *Be honest.*

A-33: I don't know.

Q-34: *No, not really? Okay. Were there some things about it you didn't like?*

- A-34: No. I don't know what I don't like but I don't like it much . . . I guess.
- Q-35: *Okay. You gave examples of other thing you did like. You talked about the Great Solar System Rescue and the thing you did in sixth grade. What was it about those programs that you liked?*
- A-35: It was fun . . . I guess because you got to do more stuff with . . . I don't . . . I guess because it was sort of like a game but the (indistinguishable) was boring.
- Q-36: *It was boring. Did your opinion of ELabBook change from when you first started to when you finished or was it the same throughout?*
- A-36: I never liked it in the beginning.
- Q-37: *So, you never liked it in the beginning and you never liked it, never liked it.*
- A-37: The only thing I liked was the last part when we put the containers together and stuff.
- Q-38: *Okay but that wasn't really part of ELabBook. That was the project.*
- A-38: Yeah.
- Q-39: *Okay. Did you think ELabBook was easy to use?*
- A-39: Sort of.
- Q-40: *In what way?*
- A-40: Because it was easy to . . . uhh, it was easy. It wasn't hard at all because I just had to know how to use a computer, I guess.
- Q-41: *Okay.*
- A-41: And know how to read.
- Q-42: *Okay. What was hard about it?*
- A-42: Some of the questions were the same questions over and over again, so that was confusing.
- Q-43: *Why was that confusing?*
- A-43: Because if you asked a different question than what you asked other than just a different form, that's all. Instead of a different question, it was the same question just wrote different.
- Q-44: *Hmmm. Okay. What did you think about those notes that you were asked to fill in?*
- A-44: Those were easy.
- Q-45: *They were easy? Okay. Why did you think that?*
- A-45: Because I just had to do the work and it would have answers.
- Q-46: *Okay. Do you think this program was of value to you in learning science?*
- A-46: Yeah, I guess.
- Q-47: *Why would you say that?*
- A-47: Because it teach you about temperature and energy, heat energy, uhh, that's it It'll help in computers, it'll teach you how to use a computer even though I already knew how to use a computer.
- Q-48: *Okay. Do you think it helped you learn anything about thermodynamics?*
- A-48: I don't even know what thermodynamics is . . . I mean, if it was explained, I would know what it was but that word, I don't know what it is.
- Q-49: *Okay. Would you want to teach someone else how to use this program?*
- A-49: No.
- Q-50: *Why not?*
- A-50: I don't know. It would take too long.
- Q-51: *Do you think you could teach them?*
- A-51: If I wanted to.
- Q-52: *Now, that's all the questions I have. Is there a general comment you want to make about ELab or about anything else?*
- A-52: Nope.
- Q-53: *Okay. I think we're all done. I'm going to shut this off now.*

- Q-1: *This is Day 1. Where we're going to start out is, I'm going to name three materials and I'd like for you to tell me if you would use them for keeping something hot, for keeping something cold, for doing both or for doing neither, okay? The first material is aluminum foil.*
- A-1: To keep something cold.
- Q-2: *Okay. Now, why would you say that?*
- A-2: Because I've done it before.
- Q-3: *Oh really, when?*
- A-3: When I was in elementary school and I'd take something to drink and I would wrap it in aluminum foil and it would keep it cold.
- Q-4: *Ummhmm . . . and did it seem to work?*
- A-4: Yeah.
- Q-5: *Is there a reason you wouldn't use aluminum foil to keep something warm?*
- A-5: No.
- Q-6: *What about wool?*
- A-6: You use it to keep something warm.
- Q-7: *Okay. Now why would you say that?*
- A-7: Because we done it on the computer.
- Q-8: *Do you remember what we did?*
- A-8: I think it was wrapping potatoes. I'm not sure.
- Q-9: *And what did you see happen?*
- A-9: It kept it warm.
- Q-10: *Okay. Would you want to use wool to keep something cold?*
- A-10: Not that I can think of.
- Q-11: *Why not?*
- A-11: I just can't think of anything.
- Q-12: *Okay. What about Styrofoam?*
- A-12: Probably keep something cold 'cause they make cups and stuff out of Styrofoam.
- Q-13: *Okay. What about to keep something warm? Would it work for that?*
- A-13: I suppose so.
- Q-14: *Okay. So, you would use it for both?*
- A-14: Ummhmm.
- Q-15: *Again, can you think of something? Do you have something in mind?*
- A-15: Nope.
- Q-16: *Okay.*
- Q-17: *All right, for this next part, I have some phrases that are written down on construction paper here and what I'd like for you to do is arrange these so that you can make a sentence that you would agree with. You might want to use all the phrases. You might just want to use some of them. What is really important is that whatever you use, that you make a sentence that you find to be true and that makes sense to you -- something, like I said, that you agree with. You want to take your time.*
- A-17: . . . (long pause) . . . I've got one.
- Q-18: *Okay. Why don't you go ahead and read what you've got there.*
- A-18: Heat stays in objects at higher temperature.
- Q-19: *Okay. Can you tell me why you'd say you agree with that?*

- A-19: 'Cause heat stays in temperature if its higher.
- Q-20: *Okay. I'm going to ask you to just tell me what you think some of these things mean. This word -- heat -- here, what do you think that means?*
- A-20: Warm. Hot.
- Q-21: *Okay, and what about this word here -- temperature?*
- A-21: A measure of heat or cold stuff.
- Q-22: *Okay. Now, I'm curious. This word here -- heat energy -- would you see this as being the same or different as heat?*
- A-22: I have no idea.
- Q-23: *Okay. Go ahead and take a guess.*
- A-23: Different.
- Q-24: *Different. Okay. What would you think this would mean -- heat energy?*
- A-24: Like energy worked up from heat.
- Q-25: *Okay. Can you tell me what is it about heat that makes it stay in objects at a higher temperature?*
- A-25: Because it's a higher temperature. Heat makes a higher temperature.
- Q-26: *Okay. So what if this was a lower temperature? Would heat stay in it or not?*
- A-26: Nope.
- Q-27: *No. What would happen?*
- A-27: It would have to be cold.
- Q-28: *Okay. So you say that cold stays in objects at a lower temperature?*
- A-28: Yes.
- Q-29: *Okay. All right. Let's talk about computers now. Oh, I guess before I do that, is there something that would illustrate this. Did you have something in mind when you said that heat stays in objects at higher temperatures?*
- A-29: Nope.
- Q-30: *Did you . . . did you . . . where did you get that from?*
- A-30: 'Cause it was like . . . kind of like the truth. It's just like heat . . . when it gets heat, it makes a higher temperature.
- Q-31: *Okay. So, that's just something you kind of picked up along the way.*
- A-31: Yeah.
- Q-32: *Okay.*
- Q-33: ***Let's think . . . think about that ELabBook Computer Program that we used. Do you remember that? What I'm going to do is, I'm going to show you this scale here and what I'd like for you to do is, I'd like for you to pick out where on this scale, you'd put ELabBook in comparison to any other computer software from all the computer software programs you've ever used? Could you read that one?***
- A-33: I picked this as the best but I did think about other ones.
- Q-34: *Okay. What is it that you liked about ELabBook?*
- A-34: It was interesting.
- Q-35: *What was interesting about it?*
- A-35: Because you could like keep heat in and keep cold in.
- Q-36: *Can you think of specific things you did with ELab that you really enjoyed? Was there like a favorite part?*
- A-36: Guessing where the heat would be when you were done.
- Q-37: *Okay. Are you sort of talking about filling out those little notes?*
- A-37: Yeah.
- Q-38: *Okay. Why did you like doing that?*
- A-38: I just thought it was interesting.
- Q-39: *Were there any other things that you liked about ELabBook?*
- A-39: Nope.
- Q-40: *Were there any things that you didn't like about it?*

- A-40: Nope.
- Q-41: *Okay. Did you . . . comparing . . . when you first started using ELabBook, did your opinion of it change as you used it more and more?*
- A-41: Nope.
- Q-42: *No? You sort of liked it from the very first time then?*
- A-42: Ummhmm.
- Q-43: *And you kept on liking it all the way through?*
- A-43: Inaudible.
- Q-44: *Okay. Did you think it was easy to use?*
- A-44: Yeah.
- Q-45: *What would you say that?*
- A-45: Because it was really self-explanatory. It wasn't hard.
- Q-46: *How was it self-explanatory?*
- A-46: It just told you what to do and stuff . . . very easy.
- Q-47: *Okay. Do you remember how it told you what to do?*
- A-47: If you followed directions, it was just easy going along with it.
- Q-48: *Okay. Do you think ELabBook was of value to you in learning science?*
- A-48: Not really, unless I want to keep something warm or cold.
- Q-49: *Okay. Would you want to teach someone else how to use ELabBook?*
- A-49: Not really.
- Q-50: *No? Why not?*
- A-50: "Cause it would be . . . I don't know . . . it's kind of hard to explain it but once you start doing it, it's easy.
- Q-51: *Hmmm. Okay. Do you think you could teach them?*
- A-51: Probably.
- Q-52: *You think you are able to teach them?*
- A-52: Yeah.
- Q-53: *Okay. That's all the questions I have. But I'm curious now is if you have any comments or anything that you want to make in general about any of this stuff?*
- A-53: Nope.
- Q-54: *No? Well, that's it. I'm going to go ahead and shut this off. (END OF SIDE A AND START OF SIDE B OF TAPE 9)*



- Q-1: *This is Day 1. Okay. What I'm going to do is I'm going to name a material . . . actually I'm going to name three different materials and I'd like for you to tell me if you'd use them for keeping something hot, keeping something cold, for doing both, or for doing neither. Okay? The first material is aluminum foil.*
- A-1: Keeping something hot.
- Q-2: *Okay.*
- A-2: And cold.
- Q-3: *And cold. Okay. Why would you say that?*
- A-3: 'Cause aluminum foil, it can keep anything cold for a matter of time and it can keep something hot for a matter of time.
- Q-4: *Okay. Do you something in mind? A picture or an illustration or an experience?*
- A-4: Like . . . let's see . . . a Pepsi can. You wrap it in aluminum foil if you want to keep it cold for a while.
- Q-5: *Ummhmm. Okay. What about wool?*
- A-5: Neither.
- Q-6: *Neither. Why not?*
- A-6: 'Cause I never tried it before.
- Q-7: *Okay. Do you have a guess as to how you think it would work?*
- A-7: Let's see. I guess I would have to say "hot" because it would have . . . it would try to warm something up.
- Q-8: *Ummhmm.*
- A-8: Like when you go to sleep at night, it'll keep you warm.
- Q-9: *Okay. What about Styrofoam?*
- A-9: It would keep something cold . . . I mean hot. It would keep something hot. 'Cause I tried it and it worked.
- Q-10: *Oh really, where did you try at?*
- A-10: In Miss Cain's (transcription note: sounds like Cain) class.
- Q-11: *What did you do?*
- A-11: We put . . . we wrapped . . . we packed aluminum foil paper around it and then we put some hot water inside it and then we dipped it in cold water to see how long it would stay hot. And then we put some hot water inside it and then we dipped it in cold water to see how long it would stay hot.
- Q-12: *Okay. What is it about Styrofoam that makes it work so well for that?*
- A-12: I really don't know.
- Q-13: *What about wool or aluminum foil?*
- A-13: Aluminum foil? I guess 'cause it's solid. It's a solid material but you still can wrinkle it up.
- Q-14: *Okay. Why does that make it work for keeping something hot or cold?*
- A-14: Well, you can like wrap stuff around it. You can wrap . . . well, you can wrap stuff around it and it around stuff.
- Q-15: *Okay.*
- Q-16: *Next, what I have here is, I have some phrases that are written down and what I'd like for you to do is try to make up a sentence out of these phrases. Now, you don't have to use all of them but if you want to use all of them, you certainly can. But what's most important is that whatever you use, you make a sentence that makes sense to you or something you would agree with or something you think is true. Go ahead and take your time.*

- A-16: . . . (long pause) . . . I want to add at the end.
- Q-17: *Okay. What do you want to add?*
- A-17: Heat energy flows around cold objects.
- Q-18: *Okay. Did you want to add something there at the end? Is that what you said?*
- A-18: Well, let me see . . .
- Q-19: *If there's a phrase that you want to use that's not there, you can just . . . we'll just say its there and you can just mention it.*
- A-19: I've got it . . . Energy . . . heat energy is present in cold energy.
- Q-20: *Okay. Now, can you tell me why you'd agree with that or think that's true?*
- A-20: 'Cause it's easier to make something hot than it is to make something cold. 'Cause you can like put it . . . you could set water out and it'll stay warm for many times but you have to put this in the freezer so it'll take longer so that all the water can freeze before it turns to ice.
- Q-21: *Okay. I'm going to ask you what some of these terms would mean . . . right here -- heat energy. What does that mean?*
- A-21: Let's see . . . like heat when it combines . . . heat can keep you warm at night when it's combined with energy.
- A-22: *Okay. What about this one here -- cold energy?*
- A-22: It's . . . it's like air conditioning . . . cold energy . . . it keeps you cool.
- Q-23: *Ummhmm. Okay. What about this term here -- flows?*
- A-23: Umm, let's see. If you put heat . . . if you put these two together, it would like flow into each other so it would like make you hot and warm and it would be warm.
- Q-24: *Okay. Where did you pick this up . . . this idea from?*
- A-24: After we did . . . after we did the project . . . our last project . . . about the water when we stuffed Styrofoam.
- Q-25: *Ummhmm.*
- A-25: I thought about it. After the (indistinguishable), we should have had this because the cold was like inside the heat.
- Q-26: *Okay. Just so we'll know on the tape, what you did is, you switched the cold energy and the heat energy.*
- A-26: Yeah.
- Q-27: *Okay. And you think it should be that way because?*
- A-27: Because the cold water . . . we have more cold water and less hot water so I would suspect that the cold water . . . some of the cold water did go inside the heat . . . into the warm water.
- Q-28: *Okay. What do you think caused that to happen?*
- A-28: What caused what to happen?
- Q-29: *What you just said.*
- A-29: Well see . . . cold water. What you mean by that?
- Q-30: *Well, you just said the cold water . . . that some of the cold water got into the hot water.*
- A-30: Oh yeah. Okay. Say if you like could pack it all the way when you get down to the end some of the cold . . . some of the water won't hold it into the thing and it went inside of it.
- Q-31: *Okay.*
- Q-32: *Okay. Let's talk about computers now. Think about that ELabBook Software that we used. Do you remember that?*
- A-32: Yeah.
- Q-33: *What I'm going to do is, I'm going to show you a scale and what I'd like for you to do is to tell me where you would rank ELabBook on this scale in comparison to all the other computer programs that you've used.*
- A-33: . . . (short pause) . . . This one (indistinguishable).

- Q-34: *Can you read that one?*  
A-34: Huh?  
Q-35: *Can you read it?*  
A-35: This is the only one I've ever used.  
Q-36: *Okay. Can you tell me why you picked that one?*  
A-36: 'Cause I never did a ELabBook before.  
Q-37: *Okay. Was there anything in particular you liked about ELabBook?*  
A-37: Let's see . . . yeah, when we did . . . when you get to click on them buttons.  
Q-38: *Yeah? Why did you like that?*  
A-38: 'Cause in the beginning and then you got to save your stuff . . . but the part I didn't like about it was when I saw Esther (transcription note: sounds like Esther) mess up your computer.  
Q-39: *When did that happen to you?*  
A-39: I . . . Some people they messed up my computer when they was messing around with my part and they messed it up, so I had to do it all over again.  
Q-40: *Ummhmm. Okay. Was there any other things about ELabBook that you liked?*  
A-40: Yeah. I liked the part what you did in the water . . . the water pocket . . . when you put it in the microwave and you put those two little beak . . . (indistinguishable) beakers.  
Q-41: *Why did you like that?*  
A-41: See because I didn't know how . . . I liked how they measured the water. I thought that was the idea there.  
Q-42: *Umm Hmmm. Was there anything else about it that you liked . . . about the program?*  
A-42: I liked the program. It was fun.  
Q-43: *Okay. Is there any thing you didn't like about it?*  
A-43: No, not really.  
Q-44: *Okay.*  
A-44: I didn't have to do nothing.  
Q-45: *Except you have to what?*  
A-45: We had to do nothing. We didn't have any real duty. We had to sit in the room. Well, my favorite part was when they tried the stuff out, to like when you had to run in place and all that. That was my favorite part.  
Q-46: *Okay. Yeah. You did that, didn't you?*  
A-46: Yeah.  
Q-47: *Yeah. Think about how you thought . . . what you thought . . . your opinion of ELabBook when you started and then your opinion as we did more and more of it. Did it change or did it stay the same?*  
A-47: Yeah. First I thought it was going to be boring but then when we got into it, it was kinda of a little fun.  
Q-48: *Why did you think it was going to be boring at first?*  
A-48: Well, ELab kinda sounds like it's going to be boring -- ELabBook. I thought it was going to be boring but when I got into it, it was fun.  
Q-49: *Did you think it was easy to use?*  
A-49: No, not really but once you learned how to do it, it was getting easy.  
Q-50: *What was hard about it? What were the hard parts?*  
A-50: To remember all your buttons, what they was and all of that. That was the hardest part.  
Q-51: *What were the easy parts?*  
A-51: Let's see . . . to find your name and all that, that was the easiest part for me.  
Q-52: *Okay. What did you think about those notes that you had to fill in?*  
A-52: The ones with numbers?  
Q-53: *Where it asked you a question and you had to fill in the rest of it.*  
A-53: It was okay but some of the notes I didn't understand (indistinguishable).

- Q-54: *Okay. Do you think this program is of value to you in learning science?*
- A-54: *In some ways, it is.*
- Q-55: *In which way.*
- A-55: *Let me see . . . in ways that now I know what can keep stuff warm and what can keep stuff hot . . . I mean cold.*
- Q-56: *Okay. Was there ways that it wasn't of any value at all?*
- A-56: *Oh, let's see . . . (short pause) . . . nothing that I can think of.*
- Q-57: *Okay. Would you want to teach someone else how to use this program?*
- A-57: *Yeah, after I learn how to do it by myself, after a while I would.*
- Q-58: *Okay, do you think you could then?*
- A-58: *Ummhmm. It looks easy.*
- Q-59: *Why do you think you'd want to teach someone else?*
- A-59: *'Cause it was fun to me. It was fun.*
- Q-60: *Okay. Now, these are all the questions that I have. I want to know if there are any general comments you want to make about ELabBook or about any of the stuff we did?*
- A-60: *No, I don't.*
- Q-61: *Okay. Well, I think that's it. I'm going to go ahead and stop this.*

- Q-1: *This is Day 1. The first thing I want to do is, I want to give you these phrases on these pieces of construction paper and what I'd like for you to do is to see if you can make a sentence out of these. Now, you can use all the phrases if you want or you can just use some of them, whichever seems to work better for you, but the really important thing is to put together a sentence that you would agree with, that you think is true, something that makes sense to you. Take your time to do this and if you need extra words, I can give you some.*
- A-1: . . . (long pause) . . . Do I have a certain time or anything?
- Q-2: *No, not at all. In fact, you can think out loud if you want to. That would be fine.*
- A-2: Oh, okay. This is like that principle thing, right?
- Q-3: *Ummhmm. Very much like it.*
- A-3: What if I get this wrong?
- Q-4: *There's no right or wrong. I'm interested in what you have to say.*
- A-4: Oh, okay.
- Q-5: *So don't worry about trying to be right or wrong.*
- A-5: . . . (long pause) . . . This is hard . . . I think the stuff that's down there is like (indistinguishable) or something.
- Q-6: *Okay. You can see there's kind of an idea here probably.*
- A-6: Yes.
- Q-7: *What would you want to say? How would you say it if you didn't have to mess with these and you had to say it in your own words?*
- A-7: Well, I would say that . . . what I learned from the project was that . . . you know how we had those two cups?
- Q-8: *Umm Hmm.*
- A-8: It uhh . . . Heat energy and cold energy both flow out at the same time because if they didn't, you know, they would be different temperatures. There was no temperature after, you know what you said. That's what I thought
- Q-9: *Just a reminder for the benefit of the tape. There was a cup that had hot water and then a bigger cup that had cold water, and you put the little one in the big one, and you're saying that . . . ?*
- A-9: I'm saying that . . . how should I say it (indistinguishable)?
- Q-10: *You said that heat flowed out of one and flowed into the other at the same time?*
- A-10: Yes.
- Q-11: *So both were happening at the same time . . .*
- A-11: Yeah
- Q-12: *. . . and ended up at room temperature . . .*
- A-12: Yes.
- Q-13: *. . . as a result? Okay. Let me ask you what some of these terms might mean to you? What does this term mean to you -- heat energy?*
- A-13: Uhh. To me, it means. I know these things. It's just hard to get it out, you know?
- Q-14: Yes. It's okay.
- A-14: It means like the heat . . .
- Q-15: *Can you give an example of it maybe, if you can't describe it?*
- A-15: Well, it's like the heat was going out of the warm cup into the cold cup.
- Q-16: *Ummhmm. Okay.*
- A-16: So it was making the . . . you know, going out of the cup.
- Q-17: *Ummhmm. Okay. What about this word here -- temperature?*
- A-17: I guess how hot or how cold something is. The degrees of (indistinguishable).

- Q-18: *The last one. . . this thing about flows. When you think about heat flowing, does that make sense to you -- heat flow?*
- A-18: Yes.
- Q-19: *Can you think of what heat flow would mean?*
- A-19: Probably 'cause it could flow into something else or it just flows. To me, it means to flow through whatever it's . . . like to flow through the room, whatever.
- Q-20: *Okay. Okay, that's good.*
- Q-21: *I'd like to ask you another couple of questions now. Here it is. Do containers or wraps that keep hot objects hot also help keep cold objects cold?*
- A-21: Yes.
- Q-22: *Okay. Why would you say that?*
- A-22: Because uhh it looks like . . . it just keeps the . . . it traps it like . . . to me, that's what it looks like. . . it traps the heat so it can't get out and it traps the coldness so it can't get out, so . . . actually mother always wraps some stuff in it and that's why I think that so but it always keeps it cold so I guess it traps it in there.
- Q-23: *Okay. What stuff did she wrap it with?*
- A-23: Like pop or something if I'm . . . 'cause you know when we're going to see the (indistinguishable) she's going to wrap up my pop in foil so that it stays colder longer and she always used to bring us stuff home from work. Before then, it would always stay hot for our ride (?) so . . .
- Q-24: *H m m m*
- A-24: And then it . . . because I think it traps it is because when you open it, it's sweaty and you can see the steam coming up so that's what I thought.
- Q-25: *What is it about that material though that you said it traps the heat in or traps the cold in, right?*
- A-25: Yeah.
- Q-26: *How does it do that?*
- A-26: Well, I have no idea.
- Q-27: *Okay.*
- Q-28: *Let's talk about computers now, okay? Think about the ELabBook Computer Program that we used. Do you remember that?*
- A-28: Ummhmm.
- Q-29: *I'm going to show you a scale here and I'd like for you to rank ELabBook on this scale in comparison with all the other ELabBook Computer Programs you've used before.*
- A-29: . . . (long pause) . . . You mean science . . . other science programs?
- Q-30: *Or actually any program at all.*
- A-30: The only other thing I've ever done on computers is games.
- Q-31: *Well, you can think of it in comparison to games.*
- A-31: Oh, well I had fun though.
- Q-32: *Would you want to pick one of these out or would you want to make your own scale?*
- A-32: That one right there.
- Q-33: *Okay. That one right there? Could you read that one?*
- A-33: I picked this as the best but I think about other ones.
- Q-34: *Okay. Now, why would you pick that one?*
- A-34: Well, really, because I had a lot of fun and I learned a lot of things from it.
- Q-35: *Okay.*
- A-35: Most of the time, you know, learning is learning but I had fun learning.
- Q-36: *What sorts of things did you learn?*
- A-36: Well, at first, I had thought I did bad and then when I picked out what I thought was

- going to be on the chart what I thought it was going to be, I thought I was going to get it wrong but I did my best, you know, I made my best decision and it turned out that I was exactly right on one of them so I learned . . . so (indistinguishable).
- Q-37: *Okay. You said you thought it was fun. What did you think was fun about it?*
- A-37: 'Cause they ask the question and then you know what they mean. It's like when teachers ask questions, they use those big words and you don't know what they're talking about. And it was fun testing the stuff and it was better than all the other classes where you sit down and write. You could type in (indistinguishable) a variety of tests (indistinguishable).
- Q-38: *Okay. Now, was there anything else . . . was there anything that you didn't like about ELabBook?*
- A-38: . . . (short pause) . . . the only thing was sometimes I had a problem with the (indistinguishable) question thing? As I said at the beginning, it was getting on my nerves.
- Q-39: *Okay. Why was that?*
- A-39: Because I couldn't get it. I would think of something but then it would be like a word was missing or something would go or, you know, something wouldn't be there.
- Q-40: *Now, think back to the time when you first tried ELabBook. Did your opinion of it change as you used it or did it pretty much stay the same?*
- A-40: Well, at first I thought it was stupid 'cause last year we never did any of that stuff and I thought it was going to be hard and I didn't want to do it but after I got started doing it, I started getting ahead of people. I just liked it.
- Q-41: *Okay. So you thought it was going to be stupid at first. Then you started liking it once you started doing it.*
- A-41: Yeah (chuckle).
- Q-42: *Okay. That's fine. Do you think it was easy to use?*
- A-42: Yeah. 'Cause the first day I . . . after the first time you explained it to me, then I got it.
- Q-43: *Umm Hmmm. Okay. What did you think about those notes that you had to fill in?*
- A-43: Well, they kinda all asked the same thing. They all asked the same question to me it sounded like so I just did the best I could.
- Q-44: *Was that good or bad that it asked the same questions a lot?*
- A-44: Some of 'em . . . well, some I didn't know how to explain it. Sometimes you just, you know, you just can't put stuff in words. It's hard to put stuff in words so really I couldn't explain it but I did my . . . I tried. That's the only thing that was hard about the questions.
- Q-45: *Do you think this program was of value to you in learning science? You kind of talked about this a little earlier.*
- A-45: I don't get it.
- Q-46: *Do you think this program was helpful in learning science?*
- A-46: Yeah. It's better than, you know, sitting in class and paying attention to the teacher. I learn easier by looking at stuff and the experience I get. I guess some people learn by listening. I learn by doing and doing.
- Q-47: *Okay. Would you want to teach someone else this program*
- A-47: Yeah. I think it would be fun.
- Q-48: *Yeah? Why?*
- A-48: Because it was easy to do and I think that everybody . . . you know, they would have a chance to learn something about it. That would just be helping somebody else.
- Q-49: *Do you think you could teach them?*
- A-49: I think I could teach them.
- Q-50: *Okay. Now, that's all the questions I have to ask but I'm going to give you a chance to just make a comment about anything you did or anything we talked about.*
- (END OF SIDE B OF TAPE 9 AND START OF SIDE A OF TAPE 10)

- A-50: Umm . . . okay. I think that they should keep this program in school, you know, because its easy for the kids to learn about heat energy, and if it's fun and they wouldn't be all just sitting there, they'd probably . . . they might want to go to class more . . .'cause it's fun. That's why I started coming to school.
- Q-51: *Okay. Great. That's it. I'm going to go ahead and shut this off now.*



- Q-1: *This is Day 1. The first thing I'm going to do is, I'm going to show you these phrases here on this construction paper and what I would like for you to do is to use these phrases to make a sentence that makes sense to you. You can use all of them. You may not want to use all of them. That's okay. It doesn't matter how many you use. What matters – what's very important – is that you make a sentence that you really think is true, that you would agree with or something that makes sense. And if you need any more phrases, let me know and I can get you some more. Take as much time as you need.*
- A-1: Do you have any more (indistinguishable) than what you have?
- Q-2: *I have duplicates of all those but if you need . . . if you want to put some other ones in there, we can just leave a spot . . .*
- A-2: Oh, okay.
- Q-3: . . . and just remember that you want to put something in there.
- A-3: . . . (long pause with voices and loud hammering noises in the background) . . . I can't make no sense out of these. They don't have the right words.
- Q-4: *Well, if you want to try and just take a whack at saying something that's in your head, that would be all right to do that.*
- A-4: Just saying something? Oh. I'll also do the one . . . heat flows from the warm body to the cold.
- Q-5: *Okay. You can use that one if you like.*
- A-5: (indistinguishable)
- Q-6: *Okay. What does that mean to you, heat flows from the warmer body to the colder?*
- A-6: That if you have like . . . like . . . like when we did those cups. . . with the cups, if you have cold water and put the hot water in there, then the hot . . . the hot water . . . the heat would go from the hot water to the cold water. Instead of the cold water making the hot water stay, the hot water makes the cold water hotter.
- Q-7: *Okay. Now, when you say "heat", what does that term "heat" mean to you?*
- A-7: Somethin' hot.
- Q-8: *Okay. What would this mean to you -- heat energy?*
- A-8: Heat energy -- like a light bulb or somethin'?
- Q-9: *Whatever you think it might be.*
- A-9: I don't know . . . like . . . I don't know . . . like a light bulb or a blow dryer or somethin'.
- Q-10: *Okay. Do you think these two are the same -- heat and heat energy?*
- A-10: They can be but I don't think that they're the exact same.
- Q-11: *How would they be different?*
- A-11: Like . . . let me see . . . like, I don't know, like a cup of hot water would be . . . oh yeah, they are the same. I would say they're the same.
- Q-12: *Okay. What about this word here -- temperature? What would you say that is?*
- A-12: It'd be like (loud hammering in the background) . . . how hot or cold it is.
- Q-13: *Okay.*
- A-13: . . . probably?
- Q-14: *Okay. And you used the word "flow", what would that word mean to you . . . when you were talking about "heat flowing"?*
- A-14: It means heat going . . . going from hotter to cold.
- Q-15: *Okay. That's all there is for that.*
- Q-16: *The next question I'd like to ask you is, if you had a container or a wrap of some kind, would that container or wrap, if it kept something hot, could it also keep*

*something cold?*

A-16: Yeah.

Q-17: *Does it always?*

A-17: No. For a while maybe it could.

Q-18: *What . . . when would it be able to do both?*

A-18: If . . . I don't know.

Q-19: *When would it just be able to do one or the other?*

A-19: That's like . . . if you wrapped like a sandwich of pastrami in aluminum foil and you wrapped some ice in it, it wouldn't stay cold.

Q-20: *Okay. How do you know that?*

A-20: 'Cause I tried it before just after we started playing around with the thing.

Q-21: *You wrapped a sandwich with . . . how did you do it? You wrapped a sandwich with aluminum foil . . .*

A-21: . . . and wrapped some ice in aluminum foil in either side and set it on the table.

Q-22: *And what happened?*

A-22: And they (indistinguishable) at the same time.

Q-23: *Okay. So, what do you think . . . let's go back to what I asked you first. Can you think of something that would (loud pounding noises in background) work with both?*

A-23: No. Both? No.

Q-24: *Okay. What is it that helps keep things hot or helps keep things cold.*

A-24: Why do it . . . ?

Q-25: *Umm Hmmm.*

A-25: Because it keeps the heat in there. It would be like, if it's wrapped around there, heat can't get out. That's easy.

Q-26: *Okay. Now, how about for keeping something cold?*

A-26: It would keep heat from gettin' in there . . . from gettin' in.

Q-27: *Okay.*

Q-28: *Let's talk about computers now, okay. Think about that ELabBook Computer Program that you used in class. Do you remember that?*

A-28: Ummhmm.

Q-29: *Okay. Now, I'm going to show you a scale here and I'd like for you to look at . . . look at these items and rank where ELabBook would fall on this scale compared to any other computer . . . compared to all the other computer programs you've ever used before.*

A-29: The second one.

Q-30: *Okay. Can you read that one?*

A-30: I picked this as the best but I did think about others.

Q-31: *Okay. Now, why would . . . why would you pick that one?*

A-31: It was funer (more fun). There was more stuff to do on there.

Q-32: (loud hammering noises in the background) *What do you mean there was more stuff to do?*

A-32: Well, you had different choices and you could pick which one.

Q-33: *Can you give me an example?*

A-33: Like you could pick which one you wanted to wrap it with and stuff like that. You just got to do more.

Q-34: *As compared to what?*

A-34: Like . . . well, nothing that I can think of right now but in other ones that we used, you just don't really do nothing.

Q-35: *Hmmm. Okay.*

A-35: You just answer questions.

- Q-36: *Was there anything else?*  
A-36: Nothing else.
- Q-37: *I'm sorry? Go ahead.*  
A-37: (indistinguishable due to loud hammering noises in background)
- Q-38: *Was there anything else about ELabBook that you enjoyed or that you liked?*  
A-38: No.
- Q-39: *Was there anything about ELabBook that you didn't like?*  
A-39: No, not really.
- Q-40: *Okay. Now, think back when you first started to use ELabBook, did your opinion of it change from the time you first started to until later one, or did it stay about the same?*  
A-40: It stayed about the same.
- Q-41: *So you kind of always thought it was pretty . . . you liked it from the start?*  
A-41: Umm Hmmm.
- Q-42: *Did you think it was easy to use?*  
A-42: No, it wasn't easy but it wasn't hard.
- Q-43: *Okay. What was hard about it?*  
A-43: It wasn't really hard. You just had to think about stuff and you couldn't just press a button and answer it right there.
- Q-44: *Okay, like what stuff, for instance . . .*  
A-44: And we had to pay attention in class and stuff to know the answer (humorous tone).
- Q-45: (Slight chuckle) *Yeah, that's true. What sort of things did you have to . . . can you think of an example of something where you had to pay attention?*  
A-45: Like when they asked those questions about . . . the questions that you got to answer at the end? You had to . . . like your partner couldn't do it right away . . . you had to pay attention to what your results were after you did the experiment.
- Q-46: *Okay. What did you think about those notes that you had to fill out?*  
A-46: They was all right because they helped you learn more it because you had to think about it.
- Q-47: *Okay. So, do you think this program was of value to you in learning science?*  
A-47: Yeah.
- Q-48: *How so?*  
A-48: Because we learned about heat and heat energy and stuff, and if we would have just talked about it, we probably wouldn't have been paying attention.
- Q-49: *Hmmm.*  
A-49: And we wouldn't have remembered it.
- Q-50: *But you think you remembered it better?*  
A-50: Yeah, you wouldn't have just remembered it for the test but you would just remember it just enough.
- Q-51: *Oh, okay. Would you want to teach someone else how to use this program?*  
A-51: No. I don't like teaching.
- Q-52: *No?*  
A-52: 'Cause I don't have no (indistinguishable).
- Q-53: *Do you think you could teach someone?*  
A-53: Yeah, I could.
- Q-54: *In other words, do you know the program well enough to be able to teach it?*  
A-54: Yeah.
- Q-55: *Okay. Now, that's all the questions that I wanted to ask but I wanted to give you a chance to make a comment on anything we've talked about here or anything about the stuff we've done. Do you have a comment you want to make?*  
A-55: No.
- Q-56: *Okay. Then, that's it. I'm going to go ahead and shut this off.*  
A-56: Okay.

- Q-1: *This is Day 1. What I'm going to do is, I'm going to name three different materials and I would like for you to tell me if you would use each of these materials for keeping something hot, for keeping something cold, for both or for neither. Okay?*
- A-1: Ummhmm.
- Q-2: *The first material is aluminum foil.*
- A-2: Keeping something hot.
- Q-3: *Okay. Now, why would you say that?*
- A-3: Because it traps the steam inside and keeps it well insulated.
- Q-4: *Okay. Do you have an illustration or an example that you're thinking of when you say this?*
- A-4: Ummhmm . . . I'm not sure.
- Q-5: *Can you think of something?*
- A-5: The experiments we did in ELab thing.
- Q-6: *Okay.*
- A-6: In ELabBook in Science.
- Q-7: *Okay.*
- A-7: In the computer room.
- Q-8: *Right. Which experiment in particular?*
- A-8: The one we did with the potatoes.
- Q-9: *Okay. And what happened in that?*
- A-9: It kept it pretty warm for a while.
- Q-10: *Okay. What about for keeping something cold? Would you use aluminum foil for that?*
- A-10: You could but I don't think it would work as well.
- Q-11: *Why not?*
- A-11: I'm not sure.
- Q-12: *Okay. Second material -- wool?*
- A-12: For both.
- Q-13: *For both? Okay. Now, why would you say that?*
- A-13: The (indistinguishable) experiments that we did. The wool worked well for both of them.
- Q-14: *Ummhmm. Okay. For both of which?*
- A-14: The pot and the hot water.
- Q-15: *Okay. Do you know why wool would work well for both?*
- A-15: I'm not sure.
- Q-16: *Would you like to make a guess about it?*
- A-16: No.
- Q-17: *What about Styrofoam?*
- A-17: For keeping something hot.
- Q-18: *Okay. And why do you say that?*
- A-18: It's a good insulator and it traps the heat inside of it.
- Q-19: *How do you know Styrofoam is a good insulator?*
- A-19: In our . . . uhh . . . in our temperature difference that we did with the probes, we had Styrofoam and it worked real well.
- Q-20: *Okay. Do you know what it is about Styrofoam that makes it a good insulator?*
- A-20: I'm not sure.
- Q-21: *Okay. What about using Styrofoam for keeping something cold?*

- A-21: That works well too.
- Q-22: *Does it?*
- A-22: Ummhmm.
- Q-23: *Why do you think it does that?*
- A-23: There's cups that you can buy that have Styrofoam inside for keeping something warm or something hot.
- Q-24: *Okay. All right.*
- Q-25: *Next question is, I have some phrases that are written down on this construction paper. Do you remember this?*
- A-25: Ummhmm.
- Q-26: *Okay. So what I'm going to do is, I'm going to put these down and like we did before, what I'd like for you to do is use some or all of these phrases to make a sentence. Like I said, you can use some of them. You can use all of them. It doesn't really matter how many you use. What really matters is that whatever you come up with is something you think is true, something you would agree with, something that makes sense to you. Go ahead and take as much time as you need.*
- A-26: I'm not sure.
- Q-27: *Okay. What are you not sure about?*
- A-27: I don't know.
- Q-28: *You probably get the idea of what we're getting at here. Do you want to just try and express something in your own words?*
- A-28: I don't remember.
- Q-29: *Okay. Well, let me just ask you what some of these terms would mean then. Do you remember . . . what do you think "heat energy" would mean? What it means to you, I mean, I'm not looking for a definition. Just what does "heat energy" mean to you?*
- A-29: I don't remember.
- Q-30: *Can you make a guess, just looking at the word, what you think it would mean? Remember, I'm not looking for a particular "right answer", just what you think.*
- A-30: I don't know.
- Q-31: *What about this one here - temperature?*
- A-31: Temperature is how warm or how cold something is.
- Q-32: *Okay. What about this word over here -- heat?*
- A-32: Heat is how hot something is.
- Q-33: *Okay. What about this term here -- flows? What do you think of when you think of "flows"?*
- A-33: Uhh, I don't know.
- Q-34: *Okay. What about this term over here -- cold energy?*
- A-34: I don't know.
- Q-35: *Okay. That's fine.*
- Q-36: *Let's talk about computers now. Think about that ELabBook Computer Program that you used in class. Do you remember that?*
- A-36: Ummhmm.
- Q-37: *I'm going to show you a scale and what I'd like for you to do is to tell me which of the items on this scale you would want to rank ELabBook at in comparison to all the software programs that you've used in your life.*
- A-37: Just like all the temperature programs?
- Q-38: *No anything. Games and . . .*
- A-38: Any program?
- Q-39: *Umm Hmmm.*

- A-39: I liked it a lot.
- Q-40: *Okay.*
- A-40: It was like the top one.
- Q-41: *The top one? Go ahead and read that.*
- A-41: This is by far the best I've used.
- Q-42: *Okay. Can you tell me why you picked it that way?*
- A-42: It explains things real well so that kids can understand 'em and it makes it fun because you don't have to just sit there and read everything. You get involved with it.
- Q-43: *Umm Hmmm. Okay. Were there specific things about the program that you liked as well?*
- A-43: When we did the real thing experiments because you go to do things instead of the computer doing them for you, even though it was stuff I knew.
- Q-44: *Okay. Anything else? Anything about how the program was put together or how you used it?*
- A-44: It gave you steps to do things, like it had a checklist where you could figure out what you've already done, just in case you forgot by the next time you came back, and it showed you what you had to do next.
- Q-45: *Okay. Were there any things about ELabBook that you didn't like?*
- A-45: Hmmm uhh.
- Q-46: *No? Okay. Think back to when you first used it, okay? Did your opinion of it change any from when you first started to later on?*
- A-46: When I first started, I didn't understand how to use it but after I just kind of got into it, even later in the day the first day that I worked with it, I understood it more.
- Q-47: *Okay. So it was just a matter of . . .*
- A-47: Just getting into it.
- Q-48: *Just getting into it. Okay. Did you think it was easy to use?*
- A-48: Hmmm. Yeah, I guess because it showed you how to do things basically.
- Q-49: *Did you find . . . did you have any problems using it?*
- A-49: Umm uhh.
- Q-50: *No? Okay. What did you think about the notes that you were asked to fill in? Do you remember those notes?*
- A-50: Ummhmm. That was kind of difficult. It took a while and I didn't understand it.
- Q-51: *Why was it difficult?*
- A-51: Umm. Just that to actually put what you learned into words and like what they taught you was like broken up into different definitions and stuff and then when they put it all into one, it was kind of confusing.
- Q-52: *Okay. Did it stay . . . I mean, was it something that was hard all the way through or did it ever get easier?*
- A-52: It got easier.
- Q-53: *Now, do you think this program was of value to you in learning science?*
- A-53: Umm Hmmm.
- Q-54: *How so?*
- A-54: It teaches you new things like I never learned anything about heat energy or cold energy like that before but then once I got here, it didn't take long. It was easy to understand.
- Q-55: *Okay. What sorts of things did you learn about?*
- A-55: Just the way it works.
- Q-56: *Okay. Would you want to teach someone else how to use this program?*
- A-56: I probably could but I don't have enough patience to do it.
- Q-57: *Okay, but you think you could though?*
- A-57: Ummhmm.
- Q-58: *Okay. Those are all the questions that I had for asking you but what I want to do is*

*to give you a chance to make a comment on anything that we did or any of the stuff we've talked about or anything else that we did in class.*

A-58: I liked it a lot. It was fun just being able to do stuff other than reading just straight out of the book.

Q-59: *Why do you call that fun?*

A-59: Because you get to do things. You don't have to just sit there and read everything. It's easier to understand when you do things yourself.

Q-60: *Okay. Anything else?*

A-60: Umm uhh.

Q-61: *Okay. That's it. I'm going to stop it now.*

Q-1: *This is Day 1. I have some phrases that I've printed here on construction paper and I'd like to give them to you and what I'd like for you to do . . . yeah (chuckle) you remember this, huh . . . is to come up with a sentence from these phrases. I just want to remind you that you don't have to use all of them. In fact, it really doesn't matter how many of them you use. What really matters is that the sentence that you make makes sense to you, something you agree with, something you think is true. You can use all the phrases. That would be fine if you did. If you need extra phrases, let me know and we can fill them in. Now, there's no time limit so just take your time.*

A-1: Wasn't this sentence on the computer . . . (indistinguishable)?

Q-2: *There was a sentence on the computer. I don't know that it was this exact sentence but you can construct something.*

A-2: . . . (long pause) . . . I don't know if this is right but I'll try it.

Q-3: *Okay. I'm interested in what you think, not so much in a right answer.*

A-3: Is this all right?

Q-4: *All right. Go ahead and read it.*

A-4: Heat stays in objects at a higher temperature.

Q-5: *Okay. Why don't you tell me what it is about that, that you think is . . . that you agree with?*

A-5: I'm not really sure.

Q-6: *Okay. How about if . . . I'm just going to go and ask you what some of these terms might mean to you. This one right here -- heat? What do you think that is?*

A-6: That like how hot it is outside.

Q-7: *Okay.*

A-7: How hot something is.

Q-8: *What about this word right here - temperature?*

A-8: That's the amount of degrees.

Q-9: *Okay. If I would bring this word here "heat energy" and put it here next to "heat", do you think "heat energy" and "heat" are the same, or do you think they're different?*

A-9: The same.

Q-10: *And would you tell me again what they mean again?*

A-10: It means how hot it is or something.

Q-11: *Okay. Now, why did you think that heat stays in objects at higher temperature?*

A-11: Because I wanted to get done.

Q-12: *Okay. Do you think that's true?*

A-12: It sounds like it could be.

Q-13: *Okay. How would you be able to tell if that was true or not?*

A-13: I don't know.

Q-14: *Okay. All right. What I'm going to do is I'm going to pick these up and . . .*

Q-15: *What I'm curious about is, do you think that a container or a wrap that keeps something hot would also work to keep something cold?*

A-15: Yeah.

Q-16: *Could you explain how it can do both?*

A-16: Because like . . . those thermos jugs, you know, those thermos jugs you know. Sometimes I put like . . . when it's cold, I put like hot chocolate in it, and then when



- it's warm, then I put water . . . cold water in it.
- Q-17: *Okay. Do you think this is true for any material . . . that any material can keep something hot or can keep something cold?*
- A-17: No.
- Q-18: *Which materials would it work for? Can you think of some that it would be true for that?*
- A-18: Foam.
- Q-19: *Okay. Can you think of some that would just work to keep something hot or that would just work to keep something cold?*
- A-19: Ice.
- Q-20: *Okay. What would ice be for?*
- A-20: Cold.
- Q-21: *Keeping something cold. Are you picturing something in your mind as you're saying all of this? Is there an illustration or an experiment or a situation you've seen?*
- A-21: (inaudible)
- Q-22: *No? Could you think of one?*
- A-22: Think of what?
- Q-23: *Well, like a container or a wrap that would just work for keeping something hot or keeping something cold. I mean, you mentioned "ice" but something else.*
- A-23: No.
- Q-24: Okay. Let's talk about computers now, okay?**
- A-24: All right.
- Q-25: Think about the ELabBook Computer Program that we used? Do you remember that?**
- A-25: (Inaudible)
- Q-26: *I'm going to show you a scale and what I'd like for you to do is rank ELabBook on the scale compared to any other computer program you've ever used.*
- A-26: I'll have to go by that one that you got your finger by.
- Q-27: *This one? Can you read it?*
- A-27: I picked this as the best but I did not . . . but I did think about other ones.
- Q-28: *Okay. Why would you say that one?*
- A-28: Because my friends got a computer that I use.
- Q-29: *Okay. So, what is it about ELabBook that made you say that?*
- A-29: Because it was easy.
- Q-30: *Okay. How was it easy? What was easy about it?*
- A-30: . . . (long pause) . . .
- Q-31: *Can't think of anything in particular?*
- A-31: (inaudible)
- Q-32: *Okay. Did you like ELabBook?*
- A-32: No, not really.
- Q-33: *No? Can you tell me what you didn't like about it?*
- A-33: Ahh, there were a lot of questions and stuff.
- Q-34: *You mean the questions in the notes?*
- A-34: (inaudible)
- Q-35: *Okay.*
- A-35: I didn't like understand some of them and stuff.
- Q-36: *Okay. What about them did you not understand?*
- A-36: Like what they were asking?
- Q-37: *Do you happen to remember any examples?*
- A-37: (inaudible)

- Q-38: *No? Okay. Was there anything you did like about it?*
- A-38: *I didn't have to do the written work for Mr. Cante (transcription note: sounds like Cante).*
- Q-39: *Okay. Now, did your opinion about ELabBook change from the time you first started to use it to the time you were finished using it? Did it change at all or did it stay the same?*
- A-39: *I guess it stayed the same.*
- Q-40: *It stayed the same. You said you thought it was easy to use and you said that the notes . . .*
- A-40: *The questions and stuff.*
- Q-41: *You weren't always sure what to answer them.*
- A-41: *(inaudible)*
- Q-42: *What do you think could have helped you better to know?*
- A-42: *To know the answers?*
- Q-43: *Uhh Huh.*
- A-43: *. . . (long pause) . . .*
- Q-44: *I guess what I'm saying is . . . the program never really said "that's wrong" except for that one thing -- the principles thing -- so how did you know that (END OF SIDE A AND BEGINNING OF SIDE B OF TAPE 10) . . . how would you know if you were wrong?*
- A-44: *. . . (long pause) . . . I don't know.*
- Q-45: *Okay. Do you think this program was of value to you in learning science?*
- A-45: *Yeah.*
- Q-46: *Yeah? How so?*
- A-46: *Because I learned more about stuff that keeps stuff warm and how to use the computer more.*
- Q-47: *Can you think of specific things that you learned?*
- A-47: *. . . (inaudible) . . .*
- Q-48: *No? Okay.*
- A-48: *(indistinguishable)*
- Q-49: *(chuckle) Okay. Would you want to teach someone else this program?*
- A-49: *No.*
- Q-50: *No? Why not?*
- A-50: *Because I don't really know that much about it myself?*
- Q-51: *Okay. Do you think you could teach them?*
- A-51: *I could show them how to do the stuff but I probably couldn't help them answer the questions.*
- Q-52: *Okay. That's all the stuff I wanted to ask you but I want to give you a chance here at the end to make any general comment about anything we talked about here or anything we did back in class.*
- A-52: *No.*
- Q-53: *No?*
- A-53: *I think that's it.*
- Q-54: *Okay. That's all. Thank you.*

- Q-1: *This is Day 2. The way we're going to start is, I'm going to name some materials and I'd like for you to tell me if you would use them for keeping something hot, for keeping something cold, for doing both or for doing neither. Okay? The first material is aluminum foil.*
- A-1: To keep cold. (Transcription Note: The answers in this interview were so low as to be almost inaudible. The voice is difficult to hear and words difficult to distinguish.)
- Q-2: *To keep something cold? Okay. Why would you use it to keep something cold?*
- A-2: . . . (long pause) I mean, it just keeps something cold.
- Q-3: *Okay. Have you seen something that would tell you . . . I mean, have you seen something happen in your past that shows that? (Loud ringing noises in the background) What was that?*
- A-3: (Loud ringing noises continue) Like if you put something in the freezer and put the aluminum foil in it and take it somewhere, it'll keep the pop cold. It'll (indistinguishable) cold.
- Q-4: *Okay. Is there a reason why you wouldn't pick aluminum foil to keep something hot?*
- A-4: . . . I don't know of any . . .
- Q-5: *Okay. What about wool?*
- A-5: It'll probably keep something warm.
- Q-6: *You think it would keep something warm?*
- A-6: Ummhmm.
- Q-7: *Okay. Again, can you think of something . . . a reason for saying that?*
- A-7: Umm Umm (no).
- Q-8: *No? Have you seen wool do that in the past?*
- A-8: . . . (short pause) I don't know.
- Q-9: *Okay. Is there a reason why you wouldn't use wool to keep something cold?*
- A-9: Nope.
- Q-10: *No? Okay. The last material is Styrofoam.*
- A-10: Probably both.
- Q-11: *Both? Okay. Why would you say that?*
- A-11: 'Cause in some coolers there are Styrofoam so . . . and that'd probably keep it cold and it might keep something warm.
- Q-12: *Okay. How do you know that Styrofoam is in coolers?*
- A-12: Well, I seen somebody with (indistinguishable).
- Q-13: *Okay. All right. Well, we'll go on to the second part now.*
- Q-14: *I have some phrases here that I wrote out on construction paper and what I'd like for you to do . . . I'm going to arrange these here for you. What I'd like for you to do is arrange these into a sentence of some kind and it doesn't matter how many of these phrases you use. You might use all of them. You might not. You might just use a few. You might use most of them. It doesn't really matter so much how many you use. What's really important is that whatever sentence you make out of it is something that makes sense to you, or that you'd agree with, or something you think is true. So, go ahead and take your time and if you could do that, that would be great.*
- A-14: . . . (long pause) . . .
- Q-15: *Is that it? Okay, can you go ahead and read that . . . what you have there?*
- A-15: Heat energy flows in . . . heat energy flows into objects at lower temperature.

- Q-16: *Okay. Now, can you tell me why you decided to choose that?*
- A-16: ... Umm ... (long pause) ... 'Cause I was thinking about uhh ... the second one whatever it's called ...
- Q-17: *Okay.*
- A-17: ... it says that the heat goes into ... goes to a lower temperature ... colder temperatures.
- Q-18: *Okay. Now, where did you ... can you tell me what you think this term right here means -- heat energy?*
- A-18: Wherever the heat ... (long pause)
- Q-19: *If you can't think of a way to say it, maybe you can think of an example of heat energy?*
- A-19: Hmmm ... (long pause) ... I don't know.
- Q-20: *Okay. Let's look at this one -- temperature. What would you say that is?*
- A-20: Umm ... how hot or how cold something is.
- Q-21: *Okay. What is this idea of energy flowing? What does that say? Or heat energy flowing? What does that say to you about?*
- A-21: I don't know.
- Q-22: *Okay. What were you thinking of when you ... or what do you think of when you think about heat energy flowing?*
- A-22: That it's moving.
- Q-23: (Transcription Note: The voice changed as if to say "Thank you" to someone other than the person being interviewed.) *Okay. That it's moving? Do you have an example that would illustrate this thing that you wrote down here? Something in your head where you see heat energy flowing into objects at lower temperatures?*
- A-23: The (indistinguishable) that's heating up uhh cold water.
- Q-24: *Okay. Okay. Where did you see that at?*
- A-24: Umm ... (indistinguishable) in the class.
- Q-25: *Okay. All right. I'm going to put these away now.*
- Q-26: *Now, let's talk about computers for a minute. Think about that ELabBook program that we used. Do you remember that?*
- A-26: (inaudible)
- Q-27: *Okay. I'm going to show you a scale here and I'd like for you to rank ELabBook on this scale in comparison to all the other computer programs that you've ever used.*
- A-27: This one.
- Q-28: *The second one? Could you read that one?*
- A-28: I picked this as the best but I think about other ones too.
- Q-29: *Okay. Why would you pick that for ELabBook?*
- A-29: Because I liked it and there might be other (indistinguishable).
- Q-30: *Okay. What is it that you liked about ELabBook?* (Transcription Note: There is another loud conversation that is competing for sound with this interview on the tape.)
- A-30: It was fun and (indistinguishable). (Loud background voices continue.)
- Q-31: *Now, why was it fun?*
- A-31: It was just fun. (Loud background voices continue.)
- Q-32: *Okay. Is there anything you can remember specifically that was fun about it?* (Loud background voices continue.)
- A-32: ... trying to keep ... the stuff warm and stuff like that. (Loud background voices continue.)
- Q-33: *Okay. Trying to keep the stuff warm? Okay. Was there anything about using the program that you liked?*
- A-33: ... Hmmm ... (Loud background noises continue.)
- Q-34: *Okay. Let's switch over to ... was there anything about it that you didn't like?*

- A-34: No.
- Q-35: *No? Okay. Think about the first time you used . . . you tried ELabBook. Did your opinion of it change from the first time you used it to later on, or did it pretty much stay the same?*
- A-35: It pretty much stayed the same.
- Q-36: *Okay. So you liked it from the start and you liked it all the way through it?*
- A-36: Ummhmm.
- Q-37: *Okay. Do you think that ELabBook is easy to use?*
- A-37: Ummhmm.
- Q-38: *Yes? Is there any reason that you think that?*
- A-38: I don't know.
- Q-39: *What did you think about those notes that you were asked to fill in?*
- A-39: Ummhmm.
- Q-40: *What did you think about those?*
- A-40: . . . (long pause) . . .
- Q-41: *Did you think they were easy to fill in or were they hard?*
- A-41: They were easy for me.
- Q-42: *Okay. They were easy. Why did you think they were easy?*
- A-42: Well . . . (long pause) . . .
- Q-43: *Okay. That's fine. Do you think this program was of value to you in learning science?*
- A-43: For me? Ummhmm.
- Q-44: *Yeah? Why do you think that?*
- A-44: I think it was easy.
- Q-45: *Were there . . . can you think of anything that you learned about heat when we were doing this? (The loud background noises continue and are now accompanied by loud hammering which makes the interview difficult to hear.)*
- A-45: (Inaudible)
- Q-46: *Could you name some?*
- A-46: Hmmm. I can't think right now.
- Q-47: *Okay. Would you want to teach someone else how to use this program?*
- A-47: I think I would.
- Q-48: *Yeah? Why?*
- A-48: 'Cause . . .
- Q-49: *Okay. Do you think you could teach them?*
- A-49: I can.
- Q-50: *Okay. Now, that's all the questions that I have for you but I want to give you a chance to make a comment on anything in particular about something we've talked about or anything else. Do you want to make any comment at all?*
- A-50: No.
- Q-51: *No? Okay. That's all. Thank you for doing this.*

- Q-1: *This is Day 2. Okay, to start with, I'm going to name some materials and I'd like for you to tell me if you would use that material for keeping something hot, keeping something cold, for doing both or for doing neither. Okay? The first material is aluminum foil.*
- A-1: Both.
- Q-2: *Okay. Why would you say that?*
- A-2: Because it's sorta like a . . . Hmmm, how would you say it? It's like . . . uhh, I'm going to use animals again . . . (chuckle) okay . . . not animals, but if I were keeping . . . if I wanted to keep something cold, aluminum foil is like sort of a metal that keeps things warm or hot . . . so it's like a backwards and forwards situation. So, I can keep anything cold or hot with aluminum foil because I guess it's like a good conduct . . . a poor conductor which means that heat can . . . it can't easily . . . well, yeah, it can't easily go through.
- Q-3: *Okay. Now, what do you mean by "a poor conductor"?*
- A-3: Umm . . . if I were to have like . . . let's see . . . Styrofoam . . . Styrofoam is a poor conductor which means you can keep something hot or cold in there for a long period of time but if it was a good conductor, then heat would be able to easily pass to and fro.
- Q-4: *Okay. Now, tell me again. Do you think aluminum foil is a good or a poor conductor?*
- A-4: It's a poor conductor.
- Q-5: *What about wool?*
- A-5: Wool is also a poor conductor because if you think about it, sheep or lambs or whatever, use wool to keep themselves warm and everything like that, so I guess it's a poor conductor.
- Q-6: *So, would you use wool for keeping something hot, cold, or neither?*
- A-6: Hot.
- Q-7: *Hot?*
- A-7: Yeah.
- Q-8: *Why would you . . . why would you not use it for keeping something cold?*
- A-8: Because it's kind of . . . wool is kind of thick and this type . . . just the kind of . . . type of material that would keep something hot. In my coat, it's like really stuffy. So . . .
- Q-9: *Okay.*
- A-9: That's it.
- Q-10: *Okay. You talked about Styrofoam before and I was going to ask you about Styrofoam.*
- A-10: Okay. Styrofoam is both because you can keep something either hot or cold because it's a poor . . . well, Hmmm, yes, it's a poor conductor. Yeah, it's a poor conductor because it would keep cold air . . . I mean, heat energy or very low energy (indistinguishable).
- Q-11: *Okay. Do you have any ideas about what makes something a good or a poor conductor?*
- A-11: Umm. Not really.
- Q-12: *How do you . . . how are you able to identify things as good or poor conductors?*
- A-12: It depends. It's like . . . you can see them in everyday life . . . like you see most people wearing wool or something like that to keep you warm during the wintertime and the wintertime is cold so it keeps heat between wool and yourself. And Styro-

foam . . . people use Styrofoam almost all the time . . . like in the wintertime they use it for coffee and in the summertime they use it for iced tea or something like that so . . .

Q-13: *Okay. That's it for that part.*

Q-14: *I have some phrases that are written on construction paper here and what I'd like for you to do is to use these phrases to make a sentence that makes sense to you. Now, you don't have to use all the phrases. You can if you want to. What's most important is that whatever sentence you make is something that you would agree with or something that you think is true or something, like I said, that makes sense to you. So, you can go ahead and take your time. Go ahead and do that if you would.*

A-14: . . . (long pause) . . . I can't make one.

Q-15: *Okay. Is there . . . do you sort of see an idea here that you can formulate into your own words maybe?*

A-15: Sort of.

Q-16: *Okay.*

A-16: I don't think I'll use cold energy so I'll just block that one out. Heat energy flows into objects at . . . (pause) . . . there's no possible words . . . that doesn't sound right but that's about the only sentence I can make out of it but I don't really understand it.

Q-17: *Okay, so why did you make that a sentence?*

A-17: Because it . . .

Q-18: *Why don't you read it, first of all?*

A-18: Heat energy flows around objects at higher and lower temperatures.

Q-19: *Now, go ahead. Why did you make that?*

A-19: Because I can't do anything else with this and it . . . okay, there's no such thing as cold energy so I blocked that one out. Heat energy . . . yes, I needed a subject and I needed a verb and I needed a . . . Hmm . . . flows around objects at higher or lower temperatures. I couldn't really say higher and not say lower so I actually put both (unrelated loud conversation starts up in the background).

Q-20: *Okay. Let me ask you this. What does this term here -- heat energy -- mean to you?*

A-20: . . . Let me think . . . I don't know . . . I guess it's like . . . something from . . . I wouldn't care to say.

Q-21: *Okay. Do you have a guess?*

A-21: Not really.

Q-22: *Okay. What about this word over here-- temperature?*

A-22: Temperature is like the measurement of something that's hot or cold.

Q-23: *Okay. What about this idea here of energy flowing around? What does that say to you?*

A-23: It's sort of like a atom. (A loud conversation starts up again in the background.) It's like . . . it's little bugs flying around an object or something like that. I guess that's heat energy, I don't know.

Q-24: *Okay and you said it needed to be both higher and lower . . . ?*

A-24: . . . Because I couldn't really say which was which because I don't really know if it is higher and lower.

Q-25: *Okay. Is there . . . you were talking about the bugs. Is there a situation that you picture in your mind when you see this or one that you think sort of gets at the idea of all of this?*

A-25: A pot.

Q-26: *A pot.*

A-26: Umm Hmmm.

Q-27: *Like on a stove or something?*

A-27: Umm Hmmm.

- Q-28: *And then what about that?*
- A-28: Well, it's like these little . . . these little bubbles at the bottom of the pot which causes the . . . well, say for instance, all heat starts from the bottom. It starts from the bottom and rises up. If you were to cover that pot and just let the water suffocate, it couldn't evaporate because it's going towards the pot, the hot pot, then back and forth, back and forth. So, it's causing steam and stuff like that, and it's like . . . I guess it's heat energy . . . I'm not sure . . . I don't really know. I'm not that good in science yet.
- Q-29: *Hmmm. Okay. Okay. Well, that's it for that part.*
- Q-30: *Let's talk about computers right now.*
- A-30: That I can do.
- Q-31: *That you can do? Okay. Do you remember the ELabBook Program that we did?*
- A-31: Yes.
- Q-32: *What I'm going to do is, I'm going to show you this scale right here and I'd like for you to try and rank ELabBook on this scale in comparison to all the computer programs that you've ever used before.*
- A-32: I'd say it was this one.
- Q-33: *Could you read that one, please?*
- A-33: It was okay but I've never used anything I really liked. Nah, well then . . . well . . .
- Q-34: *If none of these fits, you can think of your own.*
- A-34: It was okay but it was kind of slow.
- Q-35: *That's what I was going to ask you. Tell me some things . . . some of your thoughts about it.*
- A-35: Really other than that, it was fine. It was kind of fun.
- Q-36: *What do you mean by "slow"?*
- A-36: Well, like, it took you a long time to do your data and stuff like that but I guess it was because of the computer and not the program.
- Q-37: *Umm Hmmm.*
- A-37: But other than that, it was fun.
- Q-38: *How did you know it was the computer and not the program?*
- A-38: Probably because those are later model computers and like Mr. Dakes' (transcription note: sounds like Dakes) computer which is a Macintosh, it's faster.
- Q-39: *Okay, so what were some things you liked about it, I mean, you just mentioned something here . . .*
- A-39: I liked how in the system you could browse and stuff like that and it asked for your opinions, and it made you do a little sentence and if you did it wrong, you had to do it again which took me 25 times to look at the sign but I still got it right.
- Q-40: *Were there any other things about it that you liked?*
- A-40: The materials that they used -- like cokes and potatoes and stuff we could relate to and not wheat and grain and stuff like that.
- Q-41: (chuckle)
- A-41: (chuckle)
- Q-42: *Why did you think those were better? Why were they better choices?*
- A-42: Well, because it relates to people . . . it really relates to kids and what they use, like most kids use Coke instead of Pepsi, and stuff like that, and the potatoes and chile and stuff like that.
- Q-43: *Okay. Your opinion about ELabBook, was it . . . from the first time you tried it to later on, did your opinion of it change any or did it stay pretty much the same?*
- A-43: Yeah, it changed. At first, it was like "oh, not one of these again" but as soon as I worked with it, because you can't judge a book by its cover, and as soon as I worked with it, it was okay. I got the hang of it eventually.



- Q-44: *I'm curious about that "not one of these again". What are one of these?*  
A-44: It's like you try a new . . . you try something new and it's like "please don't let it be boring". I want it to be like . . . not like the one that I had before and I don't want it to change so you know, things have to change and some things are changing and you have to change, so.
- Q-45: *Okay. Did you think it was easy to use?*  
A-45: Yeah. It was. Our teacher explained it a lot so that we could understand it and we went through it step by step so that we could understand it more, and then by the time he got finished, well, we knew how to do this and this and this. We caught on to it real fast.
- Q-46: *Okay. Do you think this program was of value to you in learning science?*  
A-46: Yes.
- Q-47: *Why would you say that?*  
A-47: Because it's like a "hands on" experience. We did something with water and stuff like that. We did the thermometer . . . or we did the thermos and stuff. And it like related to exactly what we did on the computer so it was like a real science stimulated (simulated?) experience or experiments, and stuff like that. So, I think it did.
- Q-48: *Okay. Can you think of anything in particular you learned?*  
A-48: Umm. I learned about heat energy instead of cold energy because I learned there is no such thing as cold energy and I learned really basically another experiment for next year for the science fair project.
- Q-49: *Oh, okay.*  
A-49: So.
- Q-50: *What would that be? That's okay. No one is going to hear this.*  
A-50: Oh (chuckle). I'll probably do one on chile and stuff like that. How the temperature would change if you were to wrap a wool sock around it or something like that.
- Q-51: *Now, would you want to teach someone else how to use this program?*  
A-51: Sure.
- Q-52: *Why?*  
A-52: Because it's easy and because somebody taught me how to do it, then I should be able to teach somebody else how to do it.
- Q-53: *So, you think you could do it?*  
A-53: Yeah.
- Q-54: *Okay. That's all the questions I have for you but I want to give you an opportunity to make a comment about anything we've talked about here or anything else.*
- A-54: The only comment I have is, I like the ELabBook and it's kind of fun to use and I'd recommend it for anybody who loves science.
- Q-55: *Okay. That's it. I'm going to stop it. Thanks. (END OF SIDE B OF TAPE 10 AND START OF SIDE A OF TAPE 11)*

- Q-1 *This is Day 2. Okay, here's how we'll start. I have some phrases here that are on construction paper and what I'd like for you to do is to try and make a sentence out of these. You might want to use all of these or you might not. It doesn't really matter how many you use. What's really important is that whatever sentence you make is something that makes sense to you, that you think is true or that you would agree with. You have as much time as you need so go ahead and take your time. Once you do it, we'll talk about it.*
- A-1: What kind of sentence?
- Q-2: *Any kind - a long one or short one. You can see that it's got stuff about some of the stuff we were talking about - about heat and temperature and flowing - and that . . .*
- A-2: I don't pay attention to them new stuff.
- Q-3: *What did you say?*
- A-3: I don't pay attention to them new stuff.
- Q-4: *Well, you can always try and put something together based on what you know.*
- A-4: . . . (long pause with loud shrill noises and conversations in the background)  
*Are these all just one (indistinguishable)?*
- Q-5: *Ummhmm. If you want to make some . . . make something different, then you can just tell me what they are.*
- A-5: I need a "are not".
- Q-6: *Okay. Why don't we just pretend it's in there. Just make it and leave a blank there and we'll put the "are not" in there.*
- A-6: . . . (long pause) . . . Okay.
- Q-7: *Okay? So we've got . . . go ahead and read it and just put that in there.*
- A-7: Cold energy and heat energy are not the same.
- Q-8: *Okay. Now, can you tell me why you picked that?*
- A-8: I was just guessing.
- Q-9: *Okay, so what was your guess?*
- A-9: That uhh . . . uhh . . . (chuckle) . . . that they different.
- Q-10: *Okay. What would you . . . if I were to ask you what this is -- cold energy -- what would you think that is?*
- A-10: Something like . . . real cold . . . like a high temperature or something like that.
- Q-11: *Okay. What about this one -- heat energy?*
- A-11: Something that is very hot and steam-like.
- Q-12: *Okay.*
- A-12: Steam hot.
- Q-13: *Okay. Do you have a picture in your mind with this? Are you picturing two different things when you're talking about cold energy and heat energy? Like you said "steam" for this one here. Are you picturing something over here too?*
- A-13: Uhh Uhh.
- Q-14: *No? Okay. I'm going to ask you about one other word and that's this word -- temperature. What does that mean?*
- A-14: I don't know.
- Q-15: *Well, just whatever you think. Have you ever heard that word before?*
- A-15: (chuckle) Everybody has.
- Q-16: *Okay. What does that mean to you?*
- A-16: Nothing.
- Q-17: *Just a word?*

- A-17: Yeah.
- Q-18: *Okay. When you hear the word temperature, what do you think of?*
- A-18: Like something that has different temperatures.
- Q-19: *Okay. Okay. One other thing I want to ask you is this word here -- heat -- do you think this is the same as "heat energy"? Do you see these as being the same or different?*
- A-19: I don't know. I think they're the same.
- Q-20: *They're the same? Okay.*
- A-20: Ummhmm.
- Q-21: *All right. Well, that's all for that part.*
- Q-22: *What I want to do now is I want to ask you a question and then we'll do a couple of follow-ups on that as well. What I want to ask you is this. Do you think that a container or wrap that helps to keep something hot can also be used to keep something cold?***
- A-22: It depends.
- Q-23: *And what does it depend on?*
- A-23: Well, what kind . . . what type of material it is . . .
- Q-24: *Okay.*
- A-24: . . .that's keeping it cold. There's some stuff that . . . something that keep it cold when people are hot all the time.
- Q-25: *Do you have an example?*
- A-25: and when it's cool, it cools down.
- Q-26: *It cools down. Do you have an example?*
- A-26: Uhh Uhh.
- Q-27: *Can you think of a material that . . . ?*
- A-27: Uhh . . . okay. If . . . 'cause aluminum foil, it keeps some food warm, warm-like, and it can't keep nothin' cold and I really considered milk.
- Q-28: *Okay. Have you seen this happen before somewhere?*
- A-28: Yeah . . . 'cause I've used . . . (chuckle) . . . 'cause I've used it to put some baloney in some aluminum foil and when it's wrapped up and I put it in the aluminum foil I put it in the freezer and I take it out, I say "ahhhh" because it be all soggy and warmlike.
- Q-29: *Okay. All right. Can you think of a material . . . because you said "it depends" . . . you said "it depends on the material", can you think of a material that you could use to keep something hot or to keep something cold?*
- A-29: Nope. Last time I said that . . . uhh . . . it's called a therm . . .
- Q-30: *What are you using?*
- A-30: A thermos.
- Q-31: *A thermos?*
- A-31: Yeah.
- Q-32: *Okay. And how do you know that a thermos works for both?*
- A-32: It might not. I see that mine can do it.
- Q-33: *And what do you use it for?*
- A-33: Like coffee or if he put coffee, he use my thermos.
- Q-34: *Umm Hmmm.*
- A-34: Iced coffee and tea, I guess, are some things (loud telephone rings in background).
- Q-35: *Okay. Okay. Good.*
- Q-36: *Let's talk about computers now, okay? I want you to think about that ELabBook Program that we used. Do you remember that?***
- A-36: Umm Hmmm.
- Q-37: *Okay. I'm going to show you a scale here and what I'd like for you to do is rank*

*ELabBook on this scale compared to all the other computer programs you've used and tell me where you'd put it at.*

A-37: Uhh . . . uhh . . . through.

Q-38: *This one? Can you read that one?*

A-38: It was okay but I never used any other one.

Q-39: *Okay. Were there any things about ELabBook that you liked?*

A-39: The one thing I did liked is (indistinguishable) . . . yeah . . . but I didn't like the questions.

Q-40: *You didn't like them?*

A-40: Umm Umm (no).

Q-41: *Why not?*

A-41: 'Cuz some of them I didn't understand and some of them I didn't want to do because my partner wouldn't help me and I didn't want to do them if he wouldn't.

Q-42: *Oh, okay. How come you didn't want to do them?*

A-42: Huh?

Q-43: *Why didn't you want to do them?*

A-43: 'Cuz I ain't going to . . . while they're sitting on their hands and talk while I'm doing all the work. That ain't fair.

Q-44: *Yeah, you're right. I was wondering. You said you did like the graphing?*

A-44: Ummhmm.

Q-45: *Okay. What did you like about that?*

A-45: How it was used and the way we worked.

Q-46: *Okay, how was it used, do you remember?*

A-46: Nope . . . by help, dat's all.

Q-47: *Okay. Did you think that ELabBook was easy to use?*

A-47: Yeah.

Q-48: *Did you? Why did you think that?*

A-48: 'Cuz it was easy to use.

Q-49: *What made it easy?*

A-49: Not really . . . not really, sir . . . some of it, some half of it was hard . . . kind of hard.

Q-50: *What parts were that?*

A-50: I don't remember the parts.

Q-51: *Okay. Do you remember the parts you thought were easy?*

A-51: The potatoes and . . . uhh, there was a number of them we did that I got it right on. I forgot. I don't remember.

Q-52: *Okay. Do you think that ELabBook was of value to you in learning science?*

A-52: What's that?

Q-53: *Do you think it helped you to learn science?*

A-53: Ummhmm . . . a little bit.

Q-54: *Why would you say that?*

A-54: What?

Q-55: *Why would you say that?*

A-55: 'Cuz some people that didn't know how to use ELab, well they'd know now how to use it.

Q-56: *Can you think of anything you learned using it? Anything about heat?*

A-56: Stuff that I didn't know about.

Q-57: *Can you name something?*

A-57: Umm Umm (chuckle)

Q-58: *(chuckle) Okay. Would you want to teach someone else how to use this program?*

A-58: If I really know what I'm doing, I would.

Q-59: *Okay. Do you think they'd enjoy it?*

A-59: Kind of.

Q-60: *And you think "you" could teach them?*

A-60: *Yeah.*

Q-61: *Okay. Now, that's all the questions I have for you but I want to give you a chance to make a comment on anything we've talked about here or anything that happened before. Anything you want to comment on?*

A-61: *(Inaudible)*

Q-62: *No? Okay. That's all. Thanks.*

Q-1: *This is Day 2. Okay. The way I'd like for us to start is, I've got these phrases here on construction paper and what I'd like to do is give these to you and ask you to make a sentence of some kind out of these. Now, you don't have to use all these phrases although if you want to, you certainly can. Use as many as you want. The most important thing is that whatever sentence you make is a sentence that makes sense to you or something that you think is true, something that you believe. Okay? Take your time. You have as much time as you need.*

A-1: . . . (long pause) . . . I've been thinking and I think like this. Heat stays in higher objects?

Q-2: *Okay. Heat stays in hotter objects?*

A-2: Higher.

Q-3: *Higher. Okay. Heat stays in higher objects. So we'll just get rid of that "at". Okay. Now, can you tell me why you picked that?*

A-3: I couldn't think of a sentence with (indistinguishable). Because heat, it rises, so I say that heat stays in higher objects.

Q-4: *Okay. Let me ask you this. What does this word here -- heat -- what does that mean to you?*

A-4: Warm . . . warm air.

Q-5: *Okay. So, did you have something . . . were you picturing something when you said . . . when you put this together? Was there a picture in your head of something?*

A-5: (Inaudible)

Q-6: *What was that?*

A-6: Like . . . like when . . . like . . . it's like when you're in the sun or something, like if you stand up you can feel more heat than when you lay on the ground.

Q-7: *Umm Hmmm.*

A-7: You feel more heat up in the air 'cause it rise.

Q-8: *Okay. Okay. I want to ask you about another word here . . . another word here . . . this word here -- temperature-- do you know what that word means?*

A-8: The amount of air in a room . . . I don't know.

Q-9: *That's okay. You said the amount of air in the room?*

A-9: (Inaudible)

Q-10: *Okay. Have you ever heard this word before? Okay. What about this guy -- heat energy?*

A-10: Hmmm.

Q-11: *Let me ask you this. Is heat energy the same as heat, do you think?*

A-11: Kinda.

Q-12: *How might they be the same or how might they be different?*

A-12: Because it has to do with heat.

Q-13: *Okay. So they're the same because they both have to do with heat? How about different?*

A-13: . . . (short pause) . . . I don't know.

Q-14: *Not sure. Okay. Okay. That's it for this part.*

Q-15: *Now, for the next part, what I want to do is, I want to ask you this question and then we'll do some follow-ups on that. The question I want to ask you is, do you think that a container or a wrap that can be used to keep hot objects hot can also be used to keep cold objects cold?*

- A-15: Can you repeat it?
- Q-16: *Sure. Let's say I have a container right here, or a wrap, what I'm saying is can I use any container or wrap that helps keep a hot object hot also be used to keep a cold object cold?*
- A-16: Yes.
- Q-17: *Okay. Why would you say that?*
- A-17: *'Cause I saw it done with aluminum foil.*
- Q-18: *Okay. Where did you see it done at?*
- A-18: *At my house like they cover food in pans with aluminum foil and it keep it hot and it stay warm . . . a warm temperature . . . and then they keep pops cold by wrapping them up in aluminum foil and putting them in the refrigerator and making them cold.*
- Q-19: *Okay. Can you think of other materials that would also do that besides aluminum foil?*
- A-19: Umm Umm (no).
- Q-20: *No? Do you know how aluminum foil works to do . . . why it works? What it is about aluminum foil that makes it work like you talked about? Do you think you could use another material that would work just as well?*
- A-20: Probably but not more.
- Q-21: *Okay.*
- Q-22: *Okay. Let's talk about computers. Think back to that ELabBook Program that you used in class. Do you remember that?*
- A-22: (Inaudible)
- Q-23: *Okay. What I'm going to ask you to do is look at this scale here and compare ELabBook to all the other computer programs that you've used and tell me where you think you'd rank it on this scale?*
- A-23: . . . (long pause) . . . This one.
- Q-24: *Okay, can you read that one?*
- A-24: I picked this as the best but I did think about others.
- Q-25: *Okay. Now, why did you pick that one?*
- A-25: Because I didn't think that the others that I did were as interesting.
- Q-26: *Okay. What were some things about ELabBook that you liked?*
- A-26: Drawing the graphs and stuff.
- Q-27: *Why did you like that?*
- A-27: Because I like drawing on the computers.
- Q-28: *Have you done it before?*
- A-28: (Inaudible)
- Q-29: *Okay. Were there any other things about it that you liked?*
- A-29: . . . (short pause) . . . not really.
- Q-30: *Okay. Was there anything about ELabBook that you didn't like?*
- A-30: Yeah. Our computers was messing up kinda.
- Q-31: *What happened?*
- A-31: It would erase some of our work. We would save it but it still would erase it.
- Q-32: *Hmmm. Yeah, I remember that. Did you think that was the computer or did you think that was the program?*
- A-32: Program probably.
- Q-33: *Okay. Now, think back to when you first started to use ELabBook and your opinion of it when you first used it and your opinion of it later on. Did it change any or did it stay pretty much the same?*
- A-33: It stayed pretty much the same.
- Q-34: *Okay. Okay. So you sort of liked it when you first started it and then . . .*

- A-34: (Inaudible)  
Q-35: *Okay. Did you think that it was easy to use?*  
A-35: Somewhat.  
Q-36: *In what way was it easy?*  
A-36: I really don't . . .  
Q-37: *Okay. Was there any part of it that you thought was hard?*  
A-37: (Inaudible)  
Q-38: *No? Okay. What did you think about those notes that you were asked to fill in? Remember those notes?*  
A-38: Uhh Uhh . . . Oh . . . uhh . . . notes inside the computer?  
Q-39: *Yeah.*  
A-39: Oh yeah. I remember doing those.  
Q-40: *Okay. What did you think about those?*  
A-40: They were easy because the answers was really right there on the screen.  
Q-41: *Umm Hmm.*  
A-41: So all you had to do was look at that and then fill in the blanks.  
Q-42: *Okay. Were you able to read what was on the screen and fill in the blanks usually?*  
A-42: (Inaudible)  
Q-43: *Okay. Do you think ELabBook was valuable to you in learning science?*  
A-43: Yeah. (Transcription Note: Loud dragging sound in the background as if someone was scraping concrete with a metal instrument.)  
Q-44: *How so?*  
A-44: Well, I learned more about the computers and some more things.  
Q-45: *Okay. Can you think of something specific that you learned?*  
A-45: I learned how to open up windows and I learned more about what things (indistinguishable).  
Q-46: *Okay. Now, would you want to teach someone else how to use ELabBook?*  
A-46: Yeah.  
Q-47: *Do you think so? Why would you say that?*  
A-47: Because they should learn . . . want to learn more about the heaters.  
Q-48: *Okay. Do you think you could teach them?*  
A-48: I'd probably have to learn more about the computers first and then . . .  
Q-49: *Okay. All right. Well, that's all the questions I have. What I'd like to do now is give you a chance to make a comment on anything we've talked about today or anything else? Do you want to do that?*  
A-49: (Indistinguishable)  
Q-50: *Okay. That's all. Thank you.*  
A-50: You're welcome.



- Q-1 *This is Day 2. The first thing I want to do is give you these phrases that I've got written on these slips of construction paper, and I'd like for you to arrange these in a sentence. Now, you could use all of these phrases if you want to but you don't have to. You could just use some of them. It's not really as important how many phrases you use as it is that you come up with a sentence that makes sense to you. So, like I said, the sentence should be something you agree with, something that you consider to be true, something that makes sense. Go ahead and take your time and tell me something.*
- A-1: . . . (long pause) . . . uhh, I can't make one out of this. I can't think of one off the top of my head.
- Q-2: *If there's some extra phrases that you want to make up to put in there, that'd be okay too.*
- A-2: No, that's all right. I'm (indistinguishable).
- Q-3: *Okay.*
- A-3: . . . (long pause) . . . I can't get one out of this.
- Q-4: *Okay.*
- A-4: I can't remember one anyway.
- Q-5: *Okay. Is there something that you can maybe come up with out of your head that sort of covers the same sort of ideas you see here?*
- A-5: I can't remember . . . I can't think of anything off the top of my head.
- Q-6: *Okay. Well, let me ask you about some of these terms then. This term here -- heat energy -- what does that mean to you?*
- A-6: I was just thinking back to that little project we did with the can. I was thinking about that, really, you know how to keep the heat in or cold.
- Q-7: *Umm Hmmm.*
- A-7: That's what I was thinking about here.
- Q-8: *Okay. Well, just tell me what you think this means right here. If I said "heat energy", what comes to your head?*
- A-8: Like heat . . . you know, hot . . . something hot like the sun.
- Q-9: *Okay. What about this word over here -- temperature?*
- A-9: How hot or how cold something is.
- Q-10: *Okay. Now, if I were to get this word here -- heat -- would this word "heat" mean the same as "heat energy" or are they different?*
- A-10: Uhh . . . I don't know (chuckle).
- Q-11: *Okay. Just take a guess.*
- A-11: I'd guess they'd be the same.
- Q-12: *The other word I want to ask you about is this term here -- flows. Have you ever thought about this idea of energy flowing? Or heard that before?*
- A-12: Yeah. I heard it but I never thought about it.
- Q-13: *When you think of energy flowing, what might you think about?*
- A-13: Ener . . . Energy flowing?
- Q-14: *Umm Hmmm.*
- A-14: Like maybe cold energy . . .
- Q-15: . . . or say heat energy.
- A-15: Heat energy flowing out of something like a heater, I guess.
- Q-16: *Now, you were talking about the project that you did back in class. What, in particular, were you thinking about that?*
- A-16: What I could do to keep the heat energy in.

- Q-17: . . .and?  
 A-17: Get cold.  
 Q-18: *Okay, and what did you do?*  
 A-18: What did I put on it? Well, I put some saran wrap on it and a wool sock, some aluminum foil and some tape, and it worked all right.  
 Q-19: *Okay. That's it for this part.*
- Q-20: *Now, what I want to do is, I want to ask you this other question. If I have a bunch of containers or wraps, okay, and these are all good for keeping hot objects hot, would they also be good for keeping cold objects cold?***  
 A-20: Yeah.
- Q-21: *Okay.*  
 A-21: I guess.  
 Q-22: *Okay, why would you say that?*  
 A-22: It's like it'd probably do the same thing -- hold in the heat  
 Q-23: *Umm Hmmm.*  
 A-23: And it'd probably hold in the cold too.  
 Q-24: *Umm Hmmm.*  
 A-24: That's what I'd guess. That's what I think.  
 Q-25: *Okay. How do you think they would hold in the heat or hold in the cold?*  
 A-25: Through some insulate . . . some insulation or other . . . I don't know, Styrofoam or something like that. (Transcription Note: Loud banging in the background that sounds like someone stacking chairs.) Put it in the middle between the plastic or something like that.
- Q-26: *Okay. What made you pick Styrofoam?*  
 A-26: I don't know (chuckle), just thought about it.  
 Q-27: *Okay. Have you seen Styrofoam used for something like that?*  
 A-27: I've seen a Styrofoam cooler. Those little cheap ones.  
 Q-28: *And what are those used for?*  
 A-28: To hold pop or something. To keep it cool for a little bit. You put some ice in it.  
 Q-29: *Okay. Can you think of . . . do you know of materials that would be good for keeping something hot but wouldn't be good for keeping something cold?*  
 A-29: I don't know . . . uhh . . . I don't know.  
 Q-30: *Okay. If you don't . . . you can also . . . that's okay if you can't think of any . . . maybe there aren't any.*
- 
- Q-31: *Okay. Let's talk about computers now. Think of the ELabBook Program that you used in class. Do you remember that?***  
 A-31: Yep.  
 Q-32: ***Okay. I'm going to show you a scale here and I'd like for you to rank ELabBook on this scale in comparison to all the other computer programs that you've used before.***  
 A-32: . . . (short pause) . . . I pick this one here.
- Q-33: *Could you read that?*  
 A-33: I picked this as the best but I did think about other ones.  
 Q-34: *Now, why would you pick that one for ELabBook?*  
 A-34: Well, we did that one, and we did . . . I did one last year and, you know, something similar to it but I can't remember what it was about. It was like at the beginning of the year. I think it was about . . . I forgot . . . it was something like that.
- Q-35: *Ummhmm. This is back in seventh grade?*  
 A-35: Yeah.  
 Q-36: *Okay. What is it that you liked about ELabBook?*

- A-36: Uhh, mostly, you know, doing the experiments on that and then writing in the answers to the questions. That was pretty fun.
- Q-37: *Why did you think that was fun?*
- A-37: Well, I just like answering questions, I think, you know?
- Q-38: *Okay. Was there anything else about ELabBook that you liked?*
- A-38: Not really.
- Q-39: *Okay. Was there anything about it that you didn't like?*
- A-39: No. I liked doing it.
- Q-40: *Now, think back to when you first started to use it and your opinion of it, back then, and then your opinion later on as you got to work with it. Did your opinion change any over time or was it pretty much always the same?*
- A-40: It changed because when I first started doing it, I didn't like it that much because, you know, I was a little bit lost. Once I got to know how to do it, I liked it a little bit more.
- Q-41: *Okay. Why did you think . . . why were you lost when you first started?*
- A-41: I just . . . you know, I just didn't know what I was doing really and I needed help a lot. Once I got the hang of it, it was all right.
- Q-42: *Okay. Did you think it was easy to use?*
- A-42: Uhh . . . yeah, kinda of. There were some hard parts but I got over it.
- Q-43: *What were the hard parts?*
- A-43: It was like . . . well, there really wasn't that much hard to it . . . just remember what windows to go to, to get into the ELab to open it up just to start off where you left off at. That was a little confusing sometimes.
- Q-44: *Okay. What about . . . were there parts that you thought were easy?*
- A-44: It was all kind of challenging. There really wasn't anything . . . I had to use my brain all through it.
- Q-45: *Okay. What did you think about . . . you talked a little about those notes that you were asked to fill in. What did you think about having to do those?*
- A-45: Well, it wasn't something I wanted to do but I had to do it so I did it. (END OF SIDE A AND BEGINNING OF SIDE B OF TAPE 11)
- Q-46: *Okay. So I'm going to ask you this now. Do you think this program was of value to you in learning science?*
- A-46: Uhh . . . it helped me use the computer a little bit more. I learned a little bit. I'm not saying, you know, it didn't help me learn anything at all. I learned a little bit.
- Q-47: *Can you think of something specific that you learned?*
- A-47: You know, about heat and temperature and how it rises and drops.
- Q-48: *Okay. Now, would you want to teach someone else how to use ELabBook?*
- A-48: Yeah.
- Q-49: *Why?*
- A-49: I think someone else would like it, you know, it was kind of fun to do.
- Q-50: *Ummhmm. Do you think you could teach them?*
- A-50: Yeah. It's not that hard.
- Q-51: *Okay. That's all the questions I have for you but I was wanting . . . I'm going to give you a chance to make a comment on anything we've talked about here or about anything else that you did.*
- A-51: I don't really have anything more to say.
- Q-52: *Okay. That's it. Thanks.*
- A-52: All right.

Q-1: *This is Day 2. What I'm going to do is, I'm going to name a material . . . well, I'm actually going to name three different materials and each time I name one, I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both or neither one.*

A-1: All right.

Q-2: *Okay? The first material is aluminum foil.*

A-2: For something cold . . . for keeping something cold.

Q-3: *Okay. Why would you say that?*

A-3: I just see it in a microwave . . . I mean freezer. That's how my mom uses it.

Q-4: *Okay. Why do you think she uses it?*

A-4: I guess it keeps the freshness inside there.

Q-5: *Okay. Would you ever use it for keeping something hot?*

A-5: Umm . . . no.

Q-6: *No? Why not?*

A-6: I guess if I knew, I'd use it.

Q-7: *Okay. What about wool?*

A-7: Wool. To keep myself warm, I guess.

Q-8: *Okay . . . you'd use it to keep something warm.*

A-8: Right.

Q-9: *Okay. What about to keep something cold?*

A-9: I wouldn't accept that.

Q-10: *No? Why not?*

A-10: I just use wool like when I just want to keep something warm, not cold, but to keep something warm.

Q-11: *Have you ever used wool to keep something warm before?*

A-11: A wool coat to keep yourself warm.

Q-12: *Okay. Now what about Styrofoam?*

A-12: I don't know about Styrofoam. I think I'd have to say "neither".

Q-13: *Neither one? Why not?*

A-13: I don't know. I think it'd get bowed and get hard when it gets frozen.

Q-14: *Okay. All right. That's it for that part.*

Q-15: *What I want to do now is, I have some phrases that are written on this construction paper here and what I'd like for you to do is to go through each of these phrases and see if you can make a sentence out of them. Now, you could use all of them if you want to . . . you don't have to. It's not as important how many you use. What's more important is that whatever sentence you make is something that you would agree with or something that would make sense to you, something that you think is true. Go ahead and take your time and put something together.*

A-15: . . . (long pause) . . . (Transcription Note: Loud background conversation starts up here) I think I got it now.

Q-16: *Okay. Go ahead and read that.*

A-16: Cold temperature flows into heat objects.

Q-17: *Okay. So you don't want to use the "at" here?*

A-17: No.

Q-18: *Okay. Cold temperature flows into heat objects. Okay. Now, can you tell me what you agree with that about?*

- A-18: Like cold air from a cup will rise up into the air now and the air in the room is kinda hot so, like I say, at certain degrees, the cold air will blow up into the room.
- Q-19: *Okay. Was there something you had in mind . . . a picture you had in mind . . . when you said all this?*
- A-19: Like a nice old cup of ice water. The ice water . . . the water in the ice melts into the water and it just evaporates as it gets cold and it just like gets into the room.
- Q-20: *Okay. Let me ask you . . . what is this word here -- temperature?*
- A-20: Temperature . . . uhh, temperature is like a certain degree of how cold something is or how hot it is.
- Q-21: *Okay. What about this word here -- heat?*
- A-21: Heat is like . . . uhh . . . heat is something hot . . . (indistinguishable) something hot or something warm
- Q-22: *Okay. What about this idea of temperature flow?*
- A-22: Temperature flow?
- Q-23: *Umm Hmm.*
- A-23: That's like, you know, like the cold air will flow . . . will like evaporate up in the air . . . evaporate up and then mix with the other temperature, the other air.
- Q-24: *Okay. What about this word here -- heat energy?*
- A-24: Energy. It's like, I guess, heat made by energy. It's like by moving and stuff when your body moves, it will give off heat.
- Q-25: *Okay. Do you think that heat energy and heat are the same thing?*
- A-25: Umm. Somewhat but not really. Kinda yes, I say, they're the same really.
- Q-26: *Okay. I guess that's it for that.*
- Q-27: *Why don't we go ahead and talk about computers now, okay? Think about the ELabBook Program that we did. Do you remember that?***
- A-27: Ummhmm.
- Q-28: *Okay. What I'm going to do is to show you a scale and what I'd like for you to do is to rank ELabBook on this scale somewhere in comparison to all the other computer programs that you've used before.***
- A-28: I'll take this one right here.
- Q-29: *Could you read that?*
- A-29: It was okay but I've never used anything I really liked.
- Q-30: *Okay. Can you tell me why you picked that one?*
- A-30: 'Cause it's true. I haven't been using any computer that I really liked. I really need to know the keyboard pretty bad.
- Q-31: *Umm Hmm. Okay. Was there anything about ELabBook that you liked?*
- A-31: Uhh, it was . . . it was kinda fun and educational. I did learn a little something from it. I learned to work the keys and stuff like that.
- Q-32: *Okay. Was there anything else you liked about it?*
- A-32: No, that was it.
- Q-33: *Okay.*
- A-33: That "real time" too, I liked it. I liked too the statistic side and the "real time" when we done it.
- Q-34: *Okay. Was there anything about ELabBook that you didn't like?*
- A-34: The . . . my . . . my computer was too slow (indistinguishable).
- Q-35: *How do you know that?*
- A-35: I mean 'cause all that clicking and then it was waiting and then (indistinguishable) for a second and then it come on.
- Q-36: *And do you think that was the computer or do you think that was the program?*
- A-36: Probably the computer.
- Q-37: *The computer. Okay. Now, think about your opinion of ELabBook when you first started using it and then your opinion of it later on after you had been using it for a*

- while. Did your opinion change any or did it stay the same?*
- A-37: No, not really.
- Q-38: *It stayed the same the whole time?*
- A-38: It stayed the same.
- Q-39: *Okay. Do you think ELabBook was easy to use?*
- A-39: It was all right. It took a little thinking.
- Q-40: *OOP. Sorry, go ahead.*
- A-40: From time to time, it took a little thinking.
- Q-41: *Okay. What parts took the thinking?*
- A-41: Like those real times and giving the answers, answering the questions.
- Q-42: *Okay. Were there any parts you thought were easy?*
- A-42: Uhh. Not really no.
- Q-43: *Okay. What did you think of those notes that you had to fill in?*
- A-43: They were kinda hard. I always had to think what to fill in.
- Q-44: *Okay. What was hard about them?*
- A-44: Well, I would . . . well, at that time, I didn't really understand heat energy and stuff. I didn't understand the whole concept of it, so.
- Q-45: *Do you think you understand it better now?*
- A-45: A little bit. A little bit better.
- Q-46: *Okay. Do you think this program was of value to you in learning science?*
- A-46: Yes.
- Q-47: *In what way?*
- A-47: I learned how to run like a computer and I learned about heat energy.
- Q-48: *Can you think of something in particular that you learned from this?*
- A-48: Uhh, let's see. How heat travels from cold . . . I mean from smaller to bigger . . . and things like that.
- Q-49: *Okay. Now, would you want to teach someone else how to use ELabBook?*
- A-49: Oh no.
- Q-50: *No? Why not?*
- A-50: I guess I'm not a teacher. I just wouldn't want to be trying and explaining the whole process of it.
- Q-51: *So, you don't think you could teach them?*
- A-51: No.
- Q-52: *Do you think you know it well enough to teach them if you were a teacher?*
- A-52: Yes, I could. I just wouldn't want to.
- Q-53: *Okay. Now, that's all the questions I have for you. What I'd like to do is give you a chance to make a comment on anything we've talked about here or about anything we did over there.*
- A-53: Okay, by the way, it was just fun to do but sometimes, I did get a little bored and stuff instead of hanging and just get over it, and get it over with.
- Q-54: *What parts were fun?*
- A-54: Let's see. Part of the fun I liked was like the first part of it. I didn't like know what was going to happen. . . seeing all the charts and graphs. That was all right.
- Q-55: *Okay. What was boring?*
- A-55: Answering the questions.
- Q-56: (chuckle)
- A-56: It took too long.
- Q-57: *Okay. All right. Anything else?*
- A-57: No, that's it.
- Q-58: *Okay. That's it. Thank you.*
- A-58: All right. Bye.

Q-1: *This is Day 2. What I'm going to do is, I'm going to name three different materials and what I'd like for you to do every time I name a material is to tell me if you would use that material for keeping something hot, for keeping something cold, for doing both or doing neither. Okay?*

A-1: (Inaudible)

Q-2: *Okay. The first material is aluminum foil.*

A-2: You'd use that to keep something cold.

Q-3: *Okay. Now, why do you say that?*

A-3: Because when we did the . . . uhh . . . our things in the computer lab, we tested aluminum foil and it kept things cold.

Q-4: *Okay. Would you use aluminum foil to keep something warm?*

A-4: Umm Hmmm . . . sometimes but I'd use it more to keep something cold.

Q-5: *Okay. Why would you pick the cold over the warm?*

A-5: Because it seems like it keeps something cold better.

Q-6: *Do you know what it is about aluminum foil that would do that?*

A-6: No.

Q-7: *Okay. I'm going to name a second material. How about wool?*

A-7: It would keep something warm and cold -- both.

Q-8: *Both. Okay. Now, why would you say that?*

A-8: Because when we used it on our uhh thermos thing that we had to make, it kept it cold and our friends tested it in the science lab.

Q-9: *Okay. Okay. Do you know what it is about wool that makes it do both, or helps it do both?*

A-9: It's thick.

Q-10: *It's thick. Okay. What about Styrofoam?* (Transcription Note: There is a loud hammering noise in the background)

A-10: Umm. Neither.

Q-11: *Neither. Okay, now why would you say that?*

A-11: It just doesn't seem like it'd keep anything cold or warm.

Q-12: *Okay. What is it about Styrofoam that doesn't let it work very well?*

A-12: I have no idea.

Q-13: *Okay. Have you seen Styrofoam not work very well before?*

A-13: (Transcription Note: Loud background conversation is pretty loud.) Nope.

Q-14: *No? Okay. That's it for those.*

Q-15: *Now, we want to move on to the next part. I have some phrases here on construction paper and what I'd like for you to do is to take a look at these phrases . . . and what I'd like for you to do is try and construct a sentence from these. Now, I know that you may not want to use all of these or you might want to. If you want to use all of them, that's fine. What's really important though is that you come up with a sentence that you really would agree with or something that really makes sense to you, something that you think is true. You can take your time but try and come up with something. Okay?*

A-15: . . . (long pause) . . . (Transcription Note: Loud background conversation continues.) I have no idea what I'm doing.

Q-16: *Okay . . .*

A-16: It's like something scary. I think I'm missing something.

- Q-17: *Well, what other things do you wish you could put in there?*
- A-17: Hot objects (chuckle)
- Q-18: *Okay. Well, we can say that -- hot objects. You want to put "heat energy flows out of hot objects"?*
- A-18: (Inaudible)
- Q-19: *Okay. We can put that in. Pretend there is "hot objects" right here. Now, why did you pick that?*
- A-19: Because like if you have a cup of hot chocolate or somethin', heat comes out of there.
- Q-20: *Okay. Where does it go to?*
- A-20: The air (chuckle).
- Q-21: *Okay. The air. Now, why did you pick "heat energy flowing out of a hot object" instead of like a cold object?*
- A-21: 'Cause there's like heat and not cold under it.
- Q-22: *Okay. Okay. What does this word mean to you -- heat energy -- or this phrase?*
- A-22: (Transcription Note: Loud conversation continues in the background making it difficult to understand the interview.) Like when there's . . . like the steaming air coming out of the hot chocolate, or something, would that be "heat energy"?
- Q-23: *Okay. So you're thinking . . . you have a picture of hot chocolate and steam coming out of it . . .*
- A-23: Or like a little . . . little heaters that heat energy flows out of there.
- Q-24: *Okay. Okay. I'm going to point another word out, this one here -- temperature. What does that word mean?*
- A-24: How hot or cold something is.
- Q-25: *Okay. Now, I'm going to pick out another one, that's this one -- heat. Do you think "heat energy" and "heat" are the same, or do you think they're different, or . . . ?*
- A-25: I think they're different.
- Q-26: *Okay. How do you think they're different?*
- A-26: I think "heat" is just like the warmth and everything and the "heat energy" is what comes out of heat. (Transcription Note: Loud background conversation continues.)
- Q-27: *Okay. So this is what comes out of the heat and this is the warmth itself. Okay.*
- Q-28: All right. Let's talk about computers.**
- A-28: Okay.
- Q-29: *Okay. Do you remember the ELabBook software that we used?*
- A-29: Yes.
- Q-30: *Okay. I'd like for you to think about that and what I'm going to do is, I'm going to show you a temperature scale . . . I don't mean a temperature scale . . . a scale and what I'd like for you to do is tell me where you think you would rank ELabBook in comparison to all the other computer programs that you've used.*
- A-30: To like other games . . . or just other like compu . . . to other science . . . ?
- Q-31: *Anything at all. Anything at all.*
- A-31: (Transcription Note: Loud background conversation continues.) Well, not really any of these.
- Q-32: *Okay. Well, will you tell me where you would put it?*
- A-32: I liked it because it was interesting seeing, you know, you could do your own temperature and stuff and you could do your own . . . notes and experiment one on the computer behind you like some of the other like games and stuff. It was a good educational . . . (indistinguishable).
- Q-33: *Okay. What do you think is the difference between it and the games?*
- A-33: Well, the games are just like fun and you can do them on your own and you don't have to be . . . and then the computer, the science one, it was just like educational. . .
- Q-34: *Okay.*
- A-34: . . . it was fun though because we got to do our own experiments.



- Q-35: *Okay. What sorts of things did you like about ELabBook?*
- A-35: I liked where . . . when you have to . . . where we collaborate?
- Q-36: *Okay, when you had to collaborate . . .*
- A-36: . . . and we see how like the temperature changes.
- Q-37: *Umm Hmm. Okay. Was there anything else you liked about it?*
- A-37: I just liked doing the experiments and seeing it come up on the computer.
- Q-38: *Oh really. Why did you like that?*
- A-38: It was just . . . I've never done something like that before.
- Q-39: *Okay. Okay. Now, is there anything about ELabBook that you didn't like?*
- A-39: The questions, I guess . . . putting the sentences together in the questions.
- Q-40: *Oh yeah, how did you like that?.*
- A-40: I had problems with it.
- Q-41: *Why . . . What was hard about that?*
- A-41: I don't know. I just couldn't get anybody to do right.
- Q-42: *Okay. Now think about when you first started to use ELabBook, okay? And what your opinion of it was when you first started to use it and then your opinion of it as time went along. Did your opinion change at all?*
- A-42: At first when I started using it, I thought it was boring and dumb and something kind of like teachers make you do. But then after we started doing experiments on it, I thought that it was fun.
- Q-43: *Okay.*
- A-43: And picking our own materials and stuff and testing and stuff, I liked that.
- Q-44: *Now, what made you think it was going to be boring at first?*
- A-44: Just like I just thought it'd be . . . it would all be questions and we wouldn't be doing any other stuff but just answering questions and stuff.
- Q-45: *Okay. Now, you said you found out you liked being able to choose to do different things, is that what you said?*
- A-45: Yeah . . . like to choose which materials you'd like to use.
- Q-46: *Okay. Why did you like that?*
- A-46: You could have like your own thing and everyone else isn't going to have the same thing. They could have but most people didn't (indistinguishable).
- Q-47: *Okay. Now, did you think ELabBook was easy to use?*
- A-47: Yeah.
- Q-48: *Did you? Okay. Were there any parts of it that you thought were hard?*
- A-48: Just the questions (chuckle).
- Q-49: *Just the questions. What was hard about the questions?*
- A-49: Not the questions, just the way we had to put the sentence together.
- Q-50: *The sentence together, okay. That was the rough part. What about the questions -- those notes that you had to fill in. What did you think of those?*
- A-50: They were easy.
- Q-51: *Why do you think they were easy?*
- A-51: They were understandable.
- Q-52: *Okay. Okay. Now, do you think this program was valuable to you in learning science?*
- A-52: Yes. In learning science, yeah, but like I don't think I need to know it, but in school I'd need to know it.
- Q-53: *Okay. What's the difference between needing to know it in school and outside?*
- A-53: Because what I want to do when I get older, I don't think it has anything to do with what we did.
- Q-54: *What do you want to be when you get older?*
- A-54: A sports attorney.
- Q-55: *Oh, a sports attorney. Okay and so you didn't see the tie-in with this stuff here and now.*
- A-55: Yeah.

- Q-56: *But you said it was okay for doing it in school. Why do you say that?*
- A-56: Because like later on, we'll need to know how to use computers like that in school, in science.
- Q-57: *Okay. Can you think of anything specific that you learned, using ELabBook?*
- A-57: Some materials that keep things warm and cold and keep . . .
- Q-58: *Okay. Would you want to teach someone else how to use this program?*
- A-58: If they needed to know, I'd teach them but I wouldn't just want to do it because I wanted to.
- Q-59: *Okay. Do you think "you" could teach them?*
- A-59: Yeah.
- Q-60: *Okay. Now, that's all the questions I have. I'm wondering if . . . I'm going to give you a chance to make a comment on anything we've talked about here or anything else that happened out there.*
- A-60: I thought that, you know, it was fun doing it. I thought it was fun and we got to do our experiments afterwards.
- Q-61: *You thought it was fun because you like to do them yourself? Okay.*
- A-61: It wasn't just all on the computer either, you know. You got to do things with your hands.
- Q-62: *Okay. All right. Anything else?*
- A-62: No.
- Q-63: *Okay. That's all. Thank you.*
- A-63: Umm Hmmm.

- Q-1: *This is Day 2. Okay, what I'm going to do first is, I'm going to name a material and I'd like for you to tell me if you would use it for keeping something hot, for keeping something cold, for doing both, or for doing neither. Okay? The first material is aluminum foil.*
- A-1: Both.
- Q-2: *Okay, now why would you say that?*
- A-2: Because in the past I've used it to keep stuff hot and cold.
- Q-3: *Okay. Like for example?*
- A-3: Well, like pizza, you can keep it hot with aluminum foil and pop, you can keep it cold with foil.
- Q-4: *Okay. Have you done that before?*
- A-4: Ummhmm.
- Q-5: *What is it about aluminum foil that makes it work for both?*
- A-5: Well, maybe like it's kind of metal and it blocks out everything from the outside and keeps the inside . . . (Transcription Note: Loud conversation in background) like keeps the heat pressure from the inside and keeps the heat pressure from the outside . . .
- Q-6: *Okay. No, go ahead, I cut you off.*
- A-6: No, that's all.
- Q-7: *Okay. Let's try another material now -- wool.*
- A-7: Keeps it hot.
- Q-8: *Okay. Why do you say that?*
- A-8: Because they make a lot of clothes out of wool, like winter clothes.
- Q-9: *Umm Hmmm. Okay, and so those are clothes you wear to stay warm in the winter.*
- A-9: Yeah.
- Q-10: *Okay. Is there a reason you wouldn't use it to keep something cold?*
- A-10: I never heard of anybody . . . seen them use it to keep something cold.
- Q-11: *Okay. What is it about wool, do you think, that helps it to keep things hot?*
- A-11: I don't know.
- Q-12: *Okay. What about one more material -- Styrofoam?*
- A-12: It keeps stuff cold.
- Q-13: *Okay. Now, why do you say that?*
- A-13: 'Cause it's like a lot of coolers are made out of Styrofoam to keep stuff cold, when you're going to the park or something.
- Q-14: *Okay. Now, how do you know that a lot of coolers are made out of Styrofoam?*
- A-14: 'Cause I seen them at the store.
- Q-15: *Okay. Is there a reason that you wouldn't use Styrofoam to keep something hot?*
- A-15: No, not really, just never done it before. I've never used it to keep something hot.
- Q-16: *Okay. Do you think it would work to keep something hot?*
- A-16: Probably.
- Q-17: *What do you think helps Styrofoam to work to keep something cold or to keep something hot?*
- A-17: I don't know. Maybe it's just that Styrofoam are a lot of little things just compressed together.
- Q-18: *Umm Hmmm.*
- A-18: There aren't any . . . like loose . . . just stops everything.
- Q-19: *Okay. All right. Let's go on to the next part here.*

- Q-20: *Now, what I've got here are some phrases . . . do you remember this? . . . on construction paper and what I want to do is to lay these out for you, and I'd like for you to use them to make a sentence. Now, you could use some of these phrases, or you could use all of them if you want to. It doesn't . . . it's not as important how many you use. What's more important is that you construct something that you would agree with, something that's true, something that makes sense. So, take your time and go ahead and do that.*
- A-20: . . . (long pause) . . . Here you are. There's my sentence there.
- Q-21: *Okay. Go ahead and read that.*
- A-21: Heat energy stays in objects at higher temperature.
- Q-22: *Okay. Now, what made you . . . did you want to put something in there?*
- A-22: No.
- Q-23: *Now, what made you say that?*
- A-23: Because temperature, it doesn't go down, it goes up. That's how we measure the temperature -- up; and heat energy is what causes the temperature, the change in heat energy.
- Q-24: *Umm Hmmm.*
- A-24: If the heat energy like stays in something, it means it can't go out. There might be more coming in but there won't be any going out so that you get a higher temperature.
- Q-25: *Okay. What do you mean by "temperature goes up"?*
- A-25: In our measuring system, you don't measure it down, you measure it up. Just . . . it gets higher on the thing, it doesn't get lower.
- Q-26: *Okay. Okay. Do you have something . . . a picture in your head of some sort when you construct this?*
- A-26: A heater thermostat (?). That's what uhh our experiment was on, to keep it in there. When it was a higher temperature, there was more heat in the room.
- Q-27: *Okay. Now, tell me again what you think "heat energy" means?*
- A-27: Heat energy is like . . . the . . . that it makes stuff higher . . . it causes the temperature . . . because when there is a change in heat energy, that's when the temperature changes. It's nothing like cold energy. It doesn't exist. It's just that the heater gets lower as it gets higher.
- Q-28: *Okay. What about this word over here -- temperature?*
- A-28: Temperature? That's just the measurement of heat energy. It just measures it.
- Q-29: *Okay. I'm going to pick another term out of here, and that's this one here -- heat. Do you think that "heat" and "heat energy" are the same or different?*
- A-29: They're the same.
- Q-30: *Okay. All right. Were you going to say something?*
- A-30: There's another one that (indistinguishable).
- Q-31: *What would that be?*
- A-31: Like (indistinguishable) . . . I don't know . . . yeah . . .
- Q-32: *You put "heat energy flows out of objects at lower temperatures".*
- A-32: Yeah.
- Q-33: *So you made this switch. Why did you decide to do that?*
- A-33: Because the opposite was actually first.
- Q-34: *Okay.*
- A-34: It's just the opposite. Instead of staying in hotter temperature, it goes out when it's a lower temperature.
- Q-35: *Okay. Where does it go to?*
- A-35: To the colder object because it flows from hotter to colder objects.
- Q-36: *Okay. What is this idea of ener . . . of "heat energy flowing" mean?*
- A-36: Think. I think . . . I don't know but it's the second law of thermodynamics that it flows into the . . . from the hotter to the colder.

- Q-37: *Okay. Okay. And one more time. What made you decide to change again? What went off in your head?*
- A-37: *Umm. Just another sentence I could have made that gives the opposite.*
- Q-38: *Okay. Okay. So, you think this is the opposite of what you had before?*
- A-38: *(Inaudible)*
- Q-39: *Okay. All right. That's all for this.*
- Q-40: *Now, let's talk about computers. Think about the ELabBook Program that we used. Do you remember that?*
- A-40: *Ummhmm.*
- Q-41: *Okay. What I'm going to do is, I'm going to show you a scale and . . . OOPS . . . what I'd like for you to do is tell me where you think you would rank ELabBook on this scale in comparison to all the other software programs that you've used before.*
- A-41: *I think this one is mostly like it.*
- Q-42: *Okay. If there isn't one just like it, you can put your own in.*
- A-42: *Well yeah like it was okay but I have used better ones than it.*
- Q-43: *Okay.*
- A-43: *(Indistinguishable but sounds like "but I picked one".)*
- Q-44: *Okay. What did you like about it?*
- A-44: *Just that you could do more experiments. I never seen one like that before.*
- Q-45: *Umm Hmmm. Is there anything else you liked about it?*
- A-45: *That's what I liked about it. I never had seen one that you could do experiments on it.*
- Q-46: *Why would you like that? What did you like about that?*
- A-46: *'Cause . . .*  
(CHANGE TO TAPE 12)
- Q-47: *I'm going to ask that last question again. Why do you like the fact that you could do experiments?*
- A-47: *'Cause it would probably be faster doing it on the computer than the . . . like, if you did an experiment that you had to do like in thirty minutes, it would take you like longer time to do it in real life than you can do it on the computer where you can just simulate it.*
- Q-48: *Okay. How do you know that?*
- A-48: *Because that's what we did. Instead of uhh doing it in real life, we simulated it on the computer first.*
- Q-49: *Okay. Was there anything about ELabBook that you didn't like?*
- A-49: *No.*
- Q-50: *Okay. Why did you rank it as something that was good but other things are still better. What is it about the other things that made it better than ELabBook?*
- A-50: *I don't know. I just enjoyed it more, doing the other ones. I don't really . . . just . . . you know. It's funer (more fun), I guess.*
- Q-51: *Okay. That's what I'm getting at. Are there particular things on the other ones that you enjoy?*
- A-51: *Not really.*
- Q-52: *Okay. Think about the first time you used ELabBook and your opinion back then and your opinion as you used it more. Did your opinion change any or did it stay the same?*
- A-52: *Not really. It didn't change any. It stayed about the same.*
- Q-53: *Did you think that it was easy to use?*
- A-53: *Yeah.*
- Q-54: *Okay. What did you find easy about it?*
- A-54: *I didn't really find it hard. It's just easy to use and to do. If you had to do an assignment or something on it, you could just do it. It was easy.*

- Q-55: *Okay. What did you think about those notes that you were asked to fill in?*
- A-55: Those were . . . they weren't hard.
- A-56: *Okay. Why didn't you think they were hard?*
- A-56: Because it was just fast and we got done. It was just answers to the experiment that we did.
- Q-57: *Okay. Now, do you think that this program was of value to you in learning science?*
- A-57: It might be. I don't know 'cause it might be if you're going into the field of thermodynamics or something. It (indistinguishable) you like to learn experiments. If you don't, I don't know.
- Q-58: *Okay. Can you think of anything in particular you learned from it? Specifically?*
- A-58: Not really -- just what things work better to keep stuff hot or cold.
- Q-59: *Okay. What things work better?*
- A-59: It's like . . . the Styrofoam worked the best.
- Q-60: *Okay. Now, would you want to teach someone else how to use this program?*
- A-60: If they wanted to learn it. I wouldn't go around saying "Do you want to learn it". I just . . . if they wanted to learn it, I'd teach them.
- Q-61: *Okay. Why would you . . . why do you say that?*
- A-61: 'Cause it's not something I'd go around and say "Do you want to learn ELabBook? If they want to learn it, I'll teach them.
- Q-62: *Okay. Do you think you could teach them?*
- A-62: Probably.
- Q-63: *Okay. Those are all the questions that I have. What I'd like to do is to give you a chance to make a comment on anything we talked about here or anything that happened back there.*
- A-63: I don't have no more comment.
- Q-64: *None? Okay. That's it. I'm going to stop this now.*

- Q-1: *This is Day 2. Okay. So, I have some phrases that are written here on construction paper and what I'd like to do is, I'd like to arrange these and ask you to try and make a sentence out of them. Now, you can use all these phrases if you want but you don't have to. You can use as many as you want. It's not as important how many you use. What's more important is that you create a sentence that you think is true or that you would agree with, or that you think makes sense to you. Go ahead and take your time.*
- A-1: . . . (long pause) . . . This is hard. They're different than before.
- Q-2: *You've got time.*
- A-2: . . . (long pause) . . . if you like . . . if you said it like "heat energy flows into cold energy" it's like you . . . it replaces the cold energy. It always flows to the cool objects but that's the only thing that I can come close to . . . you know.
- Q-3: *Okay. Let's separate it. So, what you've got here is "heat energy flows into cold energy", okay. And what were you thinking of, again? Do you want to repeat that?*
- A-3: That heat energy, it always tries to reach a equilibrium with the cool energy . . . you know, the cooler energy.
- Q-4: *Umm Hmmm.*
- A-4: And it always . . . heat always gives off some of itself to reach the equilibrium, so it flows into the cold energy.
- Q-5: *Did you have a picture in your mind of some kind when you wrote that down or when you put that together?*
- A-5: Well, it's like, uhh . . . it's like you have two glasses of hot water and cold water and uhh you. . . but you put them into a big bowl and you put a divider into it and you have hot on one side and cold on one side. When you lift that divider up, they're not going to say they're going to try to reach the same temperature, so they have to wait and the heat has to go (?) somewhere with the heat to the cold . . .
- Q-6: *Umm Hmmm.*
- A-6: . . . which means that the heat energy moves down from the cold energy.
- Q-7: *Okay. Let me ask you this. What does this term here mean to you -- heat energy?*
- A-7: Energy created from, you know, from heat.
- Q-8: *Okay. What about this term here -- cold energy?*
- A-8: The energy that happens when you're out of heat (?).
- Q-9: *Okay. What is this idea of "heat energy flowing" supposed to mean?*
- A-9: It's like it . . . it moves . . . to where it's needed to make heat go wherever, you know, it is.
- Q-10: *Okay. What's . . .*
- A-10: And it's constantly moving.
- Q-11: *Okay. What's equilibrium again?*
- A-11: This is when . . . like hot and cold (indistinguishable) reach at the same point. They try to give . . . like the hot gives off its heat energy to make the cooler object like itself. And in order to do that, it doesn't have enough to make it as hot so it has to move 'cause it's giving away some of it. So the cool . . . the cold, it's also getting the heat energy so they can try to come to the same temperature.
- Q-12: *Okay. One last one I want to ask you about . . . well, a couple maybe. This word here -- temperature -- what does that mean to you?*
- A-12: It means how much heat energy . . . heat energy is in something.
- Q-13: *Okay and this word here -- heat -- do you think this is the same as heat energy or do you think they're different?*

A-13: It's the same.

Q-14: *They're the same? Okay. That's it for that part.*

Q-15: *Now, what I'd like to do next is ask you a question and then we'll do some follow-ups on that. The question I want to ask you is, do... does a container or wrap... containers or wraps that help... that are good for keeping hot objects hot, can they also be used to keep cold objects cold?*

A-15: (Inaudible)

Q-16: *Why do you say that?*

A-16: Because if it has the right material to keep the heat energy inside, it should have enough to keep the heat energy outside. (Indistinguishable)

Q-17: *Umm Hmm.*

A-17: So, you know, it's the same thing.

Q-18: *Okay. What is it about a material that allows it to do that ?*

A-18: If it's a good... if it's not a good conductor.

Q-19: *Okay. What does that mean?*

A-19: A good conductor is something that heat energy can pass easily through.

Q-20: *Umm Hmm.*

A-20: But a bad conductor is something that heat energy can't pass through. So, of course, it's not going to affect anything inside or outside like the cold (?) inside or outside. (Indistinguishable) (Transcription Note: Loud background conversation keeps interrupting sound.)

Q-21: *Okay. Are there particular containers that you have in mind that... when you mention all of this?*

A-21: Well, like a bad container (indistinguishable) bowl or a plate and a soup bowl (indistinguishable) really doesn't, you know, and so it's not a good container or insulator but like those juice things where you put your juice or your soup... a thermos, those are a good example of a good insulator.

Q-22: *How could you tell the difference between something that's a good conductor or something that's a good insulator?*

A-22: Well, like with some of them, they look like they might be a good conductor or have, you know, a good insulator, but you have to test; but mostly if it's real thin, you wouldn't think that it could keep a lot of heat in 'cause there's not much of it. But, usually, if it was thick or spongy or look woolly or something, you know. Then... just if it's made out of a material which you know... well, for clothing or other things, to me it's what an article or container is made out of. Naturally, it just going to be a good insulator.

Q-23: *Hmmm. Why would you think that?*

A-23: Because if like you have a sweater and you know it keeps you warm and also they've come up with this new disk container at Barber's that's made out of wool. You actually think: "yeah, that would be good because it kept me warm so why shouldn't it keep you warm." Or, if we have a bottle thermos, you say "well, it keeps the car warm, so it should keep the liquid warm." You know, just use common sense.

Q-24: *Okay. Okay. I think that's it for that.*

Q-25: *Let's talk about computers now, okay? Think about the ELabBook Program that we used in class. Do you remember that?*

A-25: (Inaudible)

Q-26: *I'm going to show you a scale and what I'd like for you to do is rank ELabBook on this scale in comparison to all the other computer programs that you've used before.*

A-26: Well, it's hard because I would say it was good. It would be sort of like this one (Transcription Note: Sounds like thumping on the table) but I would just say it was



okay.

Q-27: *Why don't you make up your own item then or just comment on what you want to say.*

A-27: Well, it was a great program and I don't usually like it before so it was a new experience. It was a good experience, you know, but I can't say it was the best program I've ever used because that would be a false statement. I could say that I picked it as the best but I did think about others because there's really no other program like it. It's the first one like that, that I've ever used and it was a good experience.

Q-28: *Okay. That's fair. What exactly did you like about it?*

A-28: It was interesting because uhh, it wasn't . . . it was complicated but it told you how to do it step by step whereas other programs, they are either too easy and you fly right through it and you actually never learn anything, or they're too difficult and there are too many complicated instructions. But this one helped you step by step and it was fairly easy because it gave you the stuff that you needed to do, so with the simulator, you know, you could do it on the computer and it would do it for you but in real times, you actually had the experience because you watched what they did so you knew how to do it in real life.

Q-29: *Hmmm. Okay. Were there any other things you liked about it?*

A-29: It was . . . it was good because you also learned the different things which you have to do to get all your research, like if you wanted to be a scientist, it's not just about doing the experiments or writing it down, you have to evaluate it and you have to think about it before you actually do the experiment. You have to get your materials and do a lot more than just experiment. You have to have a sample, neutral, all those different kinds of samples and experiments, not just doing it as if, you know, automatically as though it was happening. You have to think about what you're going to do first before you actually do it, and it's a lot more complicated than I thought.

Q-30: *Hmmm. Okay. Now, is there anything about ELabBook that you didn't like?*

A-30: It wasn't in color and you couldn't actually see the things as (indistinguishable).

Q-31: *Now, why is the color important?*

A-31: So that . . . it's okay with the different textures and the different patterns for the different things but like . . . it would just make it more interesting because just sitting around and looking at a black-and-white screen, it was interesting enough but for somebody who was colored, you know, and who really liked color, it would catch their eye so that it would actually hold their attention.

Q-32: *Why do you think color does that?*

A-32: Because it . . . there's just something about color that catches peoples' eye and if you're on a black and white, I mean, it will be interesting. You can actually see but with color, it would make it come more alive, seem more real, and it would catch your interest more.

Q-33: *Hmmm. Okay. Now, the other thing you mentioned was you wished that it showed what was happening. What exactly do you mean by that?*

A-33: Like . . . if it had uhh . . . be more animated, like if you were doing chile, you had a big, you know, piping hot bowl of chile and call it chile but you would show steam coming out of the chile or maybe the bubbles, with the both problems to solve, so you could actually see what they were doing. Because . . . I know if I was, you know, like in the next year's class and it was the same thing, I'd probably say "well, how am I supposed to know that this is actually what's happening." But if they pre-programmed it, or something like that, you know, they would be a lot different situation, you know. But if you could actually see the steam coming out . . . just little things would make it more interesting and more eye catching and (indistinguishable). That's all.

- Q-34: *Okay. Now, think about the opinion that you had of ELabBook when you first started it and then the opinion you had of it later on. Did that opinion change any?*
- A-34: Well, I liked it more, you know, I understood it more. It really . . . well, when I first worked on it, I didn't dislike it but there was just a lot of bugs. That's why it was hard to actually get into it. Once those bugs were worked out, then I understood it. Since this was the first time for most people to use it, there were going to be bugs. But after, you know, the bugs were worked out and we got it under control, then I just liked it more.
- Q-35: *Okay. Do you think it was easy to use?*
- A-35: Yeah, because it told you step by step where to go, what to do and where to tape. It started the sentences for you. I mean, it made it easier for you because some people can just sit down at something and write what they feel but other people, it's hard for them to get started so when (indistinguishable), some people their brains process more slow than other peoples so they needed the extra help, that extra start. It really . . . it was nice for some people because if . . . they can't just sit down at the computer and know what to do and figure it out (indistinguishable) because it takes them a while. They can't just figure out things. They need to be told step by step until they get the hang of it. But with other people, the program would have been okay if they did have it (?) but you can't just generalize people by some. You have to make it available to everybody.
- Q-36: *Hmmm. Okay. What did you think about the notes? You talked a little about them already. You liked that they were started for you. Any other comments about those notes?*
- A-36: It was . . . it was nice because if you just started doing it, they close the doors when you're out of school. It helped you because when you went back to those words, you saw how your opinion changed and you saw how it evolved into your final product. You could go back and say "well, I started thinking like this but at the end, I actually saw that". You could go back to them for references. It would help you think more about what you're seeing or experiencing or the experiment that you're doing. It helps you just . . . it helps you focus your attention on the experiment. It doesn't all get (indistinguishable) because you had to think on it and you had to put down what you really thought. So, it therefore saved you time.
- Q-37: *Okay. Do you think that ELabBook was valuable to you in learning science?*
- A-37: Yes. Because it helped . . . it helped me to understand it more. If I was just doing this from the book or by hand, writing it down or something, I wouldn't have been able to fully understand it but by doing it myself and figuring it out myself and sort of feeling my way through it and doing it myself, that I could understand it better and it would register better because I could actually see it.
- Q-38: *Okay. Can you . . . was there anything specific that you learned from doing this? Any specific thing?*
- A-38: I learned that the materials that you would think were weak insulators were really good insulators; and doing the simulating on the ELab, it helped with the real time when you were actually doing it for a grade with the, you know, with the containers and it helped because you knew what not to use from the experiments, you know, the experiments and you could do the experiments on Matters 1 - 3 (?), but you only had like . . . well, a very short time to do the real time and actually get a grade for it. So, it helps you to plan ahead. "I know I don't want to use this because on the simulated, it didn't do as well as another one" so you had to do a lot of different materials with the same material . . . you know, with the same product . . . so that you could compare with each other. And when you're printing it out, you could put your, you know, paper side by side and say "well, that did okay with this but when I used this with that, it did it a little better and so, if this did better than this, and this did better than this, then I should probably pick that one". You can actually see it and you can actually evaluate it more because you were doing it.

- Q-39: *Yeah. Okay. Now, would you want to teach someone else how to use this program?*
- A-39: *Yeah because I think it would be enjoyable to teach somebody because it was an enjoyable experience for me to learn it. So, you know, I wish other people would have the enjoyment of learning it too.*
- Q-40: *Okay. Do you think you could teach them?*
- A-40: *Me personally, yes, because it was such an easy program to learn, you know . . . I mean, it tells you step by step and for the people who can't understand the directions step by step, it wouldn't be that much harder to go a little further.*
- Q-41: *All right. Well, that's all the questions I have. What I want to do is give you a chance to make a comment on anything we've talked about here or done before.*
- A-41: *Well, it was . . . I think it was a good program because kids our age, they don't want to just sit looking at a textbook. That doesn't . . . we wouldn't be able to focus or learn anything but with ELabBook, and with doing the different experiments on heat energy and like that, we got to actually get a handle on everything. So, just, I mean, reading it you can understand but to actually do it, it registers better because you're actually doing it, not somebody writing a book. So, it's better for people to do "hands on experiments", especially at this age because at this age, I know personally that if I read something out of a book, it comes through and goes out somewhere and it doesn't register. But if I'm doing it, actually doing it, then it stays in my memory because I did it.*
- Q-42: *Okay. Great. Anything else?*
- A-42: *(Inaudible)*
- Q-43: *Okay. That's all. Thank you very much.*
- A-43: *Uhh Huh.*

- Q-1: *This is Day 2. I forgot to mention that we might have to flip the tape in the middle of this and if we do, we'll flip it and I might have you back up and start over again. So, what I'm going to do first of all is, I'm going to give you some phrases here and what I'd like for you to do is to try and arrange these phrases to make a sentence. You can use all of the phrases. You can use some of them. It's not as important how many phrases you use. What's more important is that you make a sentence that you'd agree with or something that you think is true or something you think makes sense. Go ahead and take your time.*
- A-1: . . . (long pause) . . . (Transcription Note: Loud conversation and noises are heard in the background.) . . .
- Q-2: *If there's a word that's missing or something, we could just pretend it's in there.*
- A-2: . . . (long pause) . . . I'm trying to remember, over there back at the lab, we had the same sentence for every one.
- Q-3: *You don't have to try . . . you don't have to try and match it identically. What's the idea you're getting? Why don't you read what you've got there so far?*
- A-3: Heat energy flows into cold objects at the same rate.
- Q-4: *Same rate? That's fine. Now what exactly does that mean to you, that sentence?*
- A-4: Like when we did those projects with the ice and the water and the hot water (indistinguishable). The hot water would go into the ice water but the ice water would also go into the hot water and make each other just the same temperature.
- Q-5: *Umm Hmmm.*
- A-5: So.
- Q-6: *Okay. When you said "at the same rate", what does that mean?*
- A-6: Like they do it at just around the same time.
- Q-7: *Okay. How would you know that?*
- A-7: Hmmm?
- Q-8: *How did you know that when you saw it?*
- A-8: Well, on the computer, we did that on little temperature things.
- Q-9: *Umm Hmmm.*
- A-9: When we'd see them, they'd like merge at around the same time.
- Q-10: *Okay. Okay. Now, let me ask you this. What does this term here mean to you -- heat energy?*
- A-10: Well, like to heat something.
- Q-11: *Okay and what about this term - flows -- this idea of energy flowing. What does that mean?*
- A-11: Like, let's say it would like move, kinda like "through things" into something else.
- Q-12: *Okay. What about this word here -- temperature?*
- A-12: How hot or cold something is.
- Q-13: *Okay and what about this word over here -- heat? Does this mean the same as "heat energy" or different?*
- A-13: Heat is how hot something is. Heat energy is like the heat that makes it hot, kind of. That's what I think.
- Q-14: *Okay. This is how hot something is and this is what makes it hot. All right. Do you have . . . you mentioned this project. Can you describe the picture in your mind as you were writing this out?*
- A-14: Well, I just . . . first, I started picturing the hot thing and then like I picture back over there in the lab.

- Q-15: *Okay. That's all for that.*
- Q-16: ***What I want to do now is ask you another question and then maybe do a couple of follow-ups on that. I want to ask you this . . . (END OF SIDE A AND BEGINNING OF SIDE B OF TAPE 12) Does a container or wrap that's good for keeping a hot object hot, would that also be good for keeping a cold object cold?***
- A-16: Sometimes.
- Q-17: *Okay. When would it be good and when wouldn't it be?*
- A-17: Like if you have aluminum foil, it's good for like keeping potatoes hot and stuff like that. Or you can stick it in the fridge and like keep pop colder or something like that.
- Q-18: *Okay. So aluminum foil is something that can do both? Is that what you're saying?*
- A-18: (Inaudible)
- Q-19: *Okay. What is it about aluminum foil that makes it special like that?*
- A-19: It's like kind of metal . . . it's kind of metal so like . . . it's kind of a conductor, I think.
- Q-20: *Okay and why does that . . . why does that make it do that?*
- A-20: . . . (short pause) . . . I don't know.
- Q-21: *Okay. Go ahead.*
- A-21: It just does.
- Q-22: *Okay. What about other materials, besides aluminum foil, can . . . are there other materials like that too?*
- A-22: . . . (short pause) . . . I can't think of any right now.
- Q-23: *Okay. Well, let me ask you this. Are there materials that would be good for keeping something hot but not good for keeping something cold, or the other way around?*
- A-23: Yeah. I guess so . . . (short pause) . . .
- Q-24: *Can you think of any?*
- A-24: Not right off the top of my head.
- Q-25: *Okay.*
- Q-26: ***Okay, let's go ahead and talk about computers now. Think about the ELabBook Program that you used in class. Do you remember that?***
- A-26: Yep.
- Q-27: ***Okay. What I'm going to do is, I'm going to show you a scale and what I'd like for you to do is to pick out where on this scale you think you would rank ELabBook in comparison to all the computer programs you've used before.***
- A-27: This one.
- Q-28: *Would you read that one?*
- A-28: It was okay but I've never used anything I've really liked.
- Q-29: *Okay. Now, why would you pick that one?*
- A-29: Well, it was okay but it took too long to do things and it wasn't really fun.
- Q-30: *Okay. Let's look at those. You said it took too long to do things. What exactly did it take too long to do?*
- A-30: Like when we'd click on something, it'd take like five minutes for it to just pull it up out of the memory.
- Q-31: *Umm Hmmm. Okay. And why didn't you like that?*
- A-31: I don't know. We only had a couple of days to do it . . . a couple of weeks, I think.
- Q-32: *Okay. So that was that. And, let's see, what was the other thing you mentioned?*
- A-32: I don't know. It left my head . . .
- Q-33: *Yeah, it just left my head too. It would be tempting to rewind this thing and see what . . . well anyway, maybe when you think about it again, let me know. Was there*

- anything you liked about it?*
- A-33: It speaks.
- Q-34: *You liked that?*
- A-34: Yeah.
- Q-35: *Why did you like that?*
- A-35: I don't know, we just . . . whenever we got done with a project or something, we'd just click on the "speak thing" and say whatever we wanted to.
- Q-36: *Hmmm. Okay. Okay. You said it was boring. That was the other thing you had down was that it was boring and that it wasn't any fun. Why would you say that?*
- A-36: Well, like you don't really do anything. You just . . . you click on something and then wait for a while and watch the water heat up and then write down a little things and you watch the water heat up again and you just don't do anything.
- Q-37: *What would you think would be better if you were to be able to change things?*
- A-37: . . . (long pause) . . .
- Q-38: *Are you having a hard time thinking of something right now?*
- A-38: (Inaudible)
- Q-39: *All right. Let me ask you this. When you first started using ELabBook, your opinion of it when you first started versus your opinion after you'd done it for a while, did your opinion of it change any?*
- A-39: It got more boring.
- Q-40: *It got more boring? And that was because?*
- A-40: Well, when we first got it, you know, we were like just playing around with it and then did a couple of experiments. It was okay. Like after the fourth experiment, we eventually (?). . . (Transcription Note: There are loud clapping rhythmical sounds which appear to be coming from the person being interviewed as if to express some kind of reaction.)
- Q-41: *Okay. Did you think it was easy to use?*
- A-41: Yeah.
- Q-42: *What did you find easy about it?*
- A-42: Like they already had the sentences typed out and like most of the questions, all you had to do was erase a couple of words and it would like type right over it, so we didn't really have to do anything real hard.
- Q-43: *Okay. Was there anything you found difficult about it?*
- A-43: I don't . . . nope.
- Q-44: *Okay. Now, what did you think about those notes we were just talking about?*
- A-44: . . . (long pause) . . .
- Q-45: *I mean, did you like them? Did you think they were kind of dopey or . . . ?*
- A-45: They were okay.
- Q-46: *They were okay. Were they easy to do?*
- A-46: Yeah.
- Q-47: *Okay. Now, do you think this program was valuable to you in learning science?*
- A-47: Probably.
- Q-48: *Okay. In what way?*
- A-48: Well, like if we become like a technician, a nuclear technician or something, we're going to have to know heat and temperatures and stuff.
- Q-49: *Hmmm. How did you happen to pick that example -- nuclear technician?*
- A-49: I don't know.
- Q-50: *Okay. Can you think of something specific you learned through the program?*
- A-50: I don't know . . . If you set something out in the room, it'll most likely always reach room temperature.
- Q-51: *Okay. Would you want to teach someone else how to use ELabBook?*
- A-51: Well, I don't think it'd be real fun, but I could.
- Q-52: *Okay. You think you could but you don't think it'd be very fun for them to do it. That's all the questions I have for you. I want to give you a chance to make a*

*comment about anything we've talked about or about anything else. Do you want to make any comment?*

A-52: I don't think so (?).

Q-53: *Okay. That's all. Thank you.*

- Q-1: *This is Day 2. What I'm going to do is, I'm going to name three materials and what I'd like for you to do is tell me if you would use each of these materials for keeping something hot, keeping something cold, doing both or doing neither. Okay? The first material is aluminum foil.*
- A-1: I would use it for something cold . . . to keep something cold.
- Q-2: *Okay. Now why do you say that?*
- A-2: Because uhh . . . I wouldn't use it for either.
- Q-3: *That's okay. You can change your mind.*
- A-3: Well, I wouldn't really use it for either because it's a poor . . . conductor . . . ahh . . . that's the confusing part . . . which one's which . . . it's bad at keeping heat energy in and out, so.
- Q-4: *Okay. So, you say it's bad at keeping energy in? And how do you know that?*
- A-4: Some of the experiments we did . . . we uhh . . . the simulations that we did . . . uhh but aluminum foil did not work as well as like paper, so, and it's something to do with some paper. It's pretty bad.
- Q-5: *Okay. All right. Here's another material -- wool.*
- A-5: I think it'd be a . . . (indistinguishable) uhh . . . it'd be good for keeping something warm.
- Q-6: *Okay. Why would you say that?*
- A-6: Because of the . . . it's a good . . . it's good at keeping heat energy in. I learned that during our last experiment and from other people's experiments.
- Q-7: *Okay. Why wouldn't you use wool to keep something cold?*
- A-7: Because . . . you know . . . when you think of wool, you don't really, you know, and . . . because, you know, it'd be trapping heat energy in more and, you know, it wouldn't be so good for keeping things cold, nor making them warm really.
- Q-8: *Okay. Another material -- Styrofoam.*
- A-8: I'd use that for both.
- Q-9: *Okay. Why do you say that?*
- A-9: Because we've used Styrofoam. It works well at keeping thing warm and I know that when my relatives have like cans of pop or something, a lot of times when we're camping, they put them in this Styrofoam like cooler holders to keep them cold so it's good at keeping things warm . . . keeping warm things warm and keeping cold things cold.
- Q-10: *Okay. Do you know what it is about these materials that makes them work as well or not as well as they do?*
- A-10: What they're made up of.
- Q-11: *Yeah.*
- A-11: Their structure.
- Q-12: *Okay. What is it about that structure?*
- A-12: Whether or not the materials are like . . . aluminum foil . . . aluminum, I guess that's the name, and so, it's kind of like, you know, I think, it's like a metal, so . . . wait a minute, what was the question? My mind went blank. . . as I said that, my mind went blank.
- Q-13: *What is it about the structure? You said it was the structure.*
- A-13: The structure. And then like things like the Styrofoam. It's just basically what it's made of.
- Q-14: *Umm Hmm.*
- A-14: You know, whether it's a good conductor or a poor conductor.



- Q-15: *Okay. All right, that's it for that.*
- Q-16: *What I want to do now is, I've got these phrases that are written down . . . do you remember this?*
- A-16: Umm Hmmm. This is cool . . . (chuckle) because now I know how to do it.
- A-17: *Well, what I'm going to do, just to give you the instructions again, is, I'm going to lay these out and ask you to make a sentence that you think makes sense. Now, you can use all the phrases if you want or you can just use some of them. It's not as important how many phrases you use. What's more important is that you make a sentence that you would agree with or that makes sense to you or something that you think is true. Go ahead and take your time.* (Transcription Note: There are many youthful voices in the background that make hearing difficult.)
- A-17: . . . (long pause) . . . Okay, I've got one now.
- Q-18: *Okay. Go ahead. Read it.*
- A-18: Heat energy flows into cold objects.
- Q-19: *Okay. You got rid of the "at"?*
- A-19: The at because I was trying to say that, you know, like the second law of thermodynamics. Heat travels from the warmer object to the colder object.
- Q-20: *Okay.*
- A-20: And.
- Q-21: *And?*
- A-21: Is there any more?
- Q-22: *That's fine. I was going to ask you, what is it that made you think that this was true or that you agree with this?*
- A-22: Would you rephrase the question?
- Q-23: *Sure. What is it that makes you think this is correct?*
- A-23: Well, it's only that's what the second law of thermodynamics is and I was like . . . that was the only thing, you know, that made sense with this, you know, with certain words missing, but that was the only thing I could think of. I could put . . . I could change it to heat but (Transcription Note: There are many youthful voices in the background that make hearing difficult.)
- Q-24: *Okay.*
- A-24: Or.
- Q-25: *Okay.*
- A-25: But that's all I can think of that would make sense because of missing words, so . . . At first I was going to try and reconstruct the principal, you know, the principal ones we did on the simulation but there weren't enough, you know uhh . . . of these so I thought about the second law of thermodynamics and that's all.
- Q-26: *Okay. Where have you seen this in action? This thing you wrote down here?*
- A-26: When we were doing the uhh . . . experiments with the uhh . . . designing our containers. We uhh . . . like the uhh . . . the heat flow out of the warm water into the cool water, taking the heat energy away from the warm water and making it cooler, so.
- Q-27: *Okay. I'm going to ask you about some of these terms here now? What is this "heat energy"? What does that mean to you?*
- A-27: It's the energy in the air, or in the something. The amount of energy, or . . . well, the amount of energy is the temperature. It's . . . (long pause with loud noises in the background). Hmmm . . . (short pause) . . . I don't know.
- Q-28: *That's okay. Let's talk about temperature, since you brought it up. What is temperature, now?*
- A-28: Temperature is the amount of energy in something.
- Q-29: *Okay, and what about this word over here -- heat -- that you talked about earlier?*
- A-29: That's . . .

- Q-30: *Do you think this is the same or different than that?*  
A-30: It seems about the same but . . .
- Q-31: *Okay, and you were going to say what you think it is?*  
A-31: Ohhhhh, think, think, think. It seems like they'd be the same but then you've got two recurring pieces of paper. (chuckle)
- Q-32: (chuckle)  
A-32: No. First of all, no, this does not exist. I remember that.  
Q-33: *What is it?*  
A-33: Cold energy does not exist.  
Q-34: *Okay.*  
A-34: So, then heat energy must. You know, it seems like "heat energy" and "heat" would be the same thing, really.
- Q-35: *Okay.*  
A-35: The heat of something, or the heat energy . . . the amount of heat energy, you know, so.  
Q-36: *Okay. Now, do you want to try and come up with another . . . what this means to you again -- heat energy ?*  
A-36: Uhh.  
Q-37: *You don't have to give me a textbook definition, just in your own words.*  
A-37: Uhh . . . it's like if, uhh . . . it's like, if there's like a cup of water here and it's like 90 degrees Celsius or something, the heat energy is what's making it warm, you know.
- Q-38: *Okay.*  
A-38: I guess.  
Q-39: *Okay.*  
A-39: (Indistinguishable) you think it (indistinguishable) for awhile.  
Q-40: *Okay. One more thing I want to ask about, this thing about heat energy flowing, what does that mean?*  
A-40: It's . . . uhh . . . well . . . it's flowing, uhh . . . like . . . it's heat energy flowing (Transcription Note: There are loud conversations going on in the background that make it difficult to distinguish what is being said in the interview.) . . . it's like . . . it's like the second law of thermodynamics, you know. You have a cup of . . . a cup of warm water and then a larger thing of cooler water. The heat energy within the warm water will flow out and heat up the water that it's in plus . . . if the like . . . air temperature . . . room temperature is lower than uhh the cup of hot water, then it could heat up the uhh . . . you know, air. It's strong.
- Q-41: *Now, you're making all these hand gestures. You've got a picture in your head. Could you describe that picture?*  
A-41: Uhh . . . it's just like . . . uhh, it's like on that test you did where we specifically, you know, talked about it and we used it on the experiment with the larger container . . . you know.  
Q-42: *That's all right. I just wanted to make sure to get it on the tape but it's from that test, from that pop quip that we had.*  
A-42: Right.  
Q-43: *Okay.*
- Q-44: *Let's talk about computers now.*  
A-44: Okay.  
Q-45: *Do you remember ELabBook?*  
A-45: Yep.  
Q-46: *Okay. What I'm going to do is, I'm going to ask you to rank ELabBook on this scale right here in comparison to all the other computer programs that you've used before. Tell me where you think you'd rate ELabBook.*  
A-46: Compared to other computer programs . . . (short pause) . . . this is confusing. This

- says I picked this as the best but . . .
- Q-47: *If there's one that you'd rank it as, that's not in here, you can make up your own ranking.*
- A-47: I'd rank it as something that it's not like the best computer program that I've used but it worked very well for teaching me about thermodynamics and how heat flows and things like that.
- Q-48: *Okay.*
- A-48: You know.
- Q-49: *Now, what would keep ELabBook from being the best program you've ever used?*
- A-49: Uhh . . . I don't know, I like more flashy kind of things that are more interactive. I mean, that was probably one of the most interactive things . . . one of the most . . . that I've had, because of the simulations and then the "real time experiments" and, you know, that kind of stuff. (Transcription Note: The loud background noises continue.) You know, it like . . . it needs more colors 'cause like the . . . more colors and more sound and, you know, things like that.
- Q-50: *Okay. Why do you think that would be good?*
- A-50: It would catch your attention more if it had more bright colors and things making it like "Oh yeah, see that", you know "hey, that looks cool", you know, and like, I don't know, I don't want to get something where it has like, you know, a little guy who's like a little teacher, being or something, some little animated character "Okay, boys and girls, we're going to learn about heat" - not like that, but, you know, just a little more than a dull black, white and gray, and things like that.
- Q-51: *Okay. Okay.*
- A-51: Plus they should use Pepsi and not Coke.
- Q-52: *Okay. I see that.*
- A-52: Yeah.
- Q-53: *What things did you like about it?*
- A-53: I liked, like I said, the way you could simulate experiments and then do almost the same kind of experiment except "real time", you know, do experiments for real with the probes and uhh, you know, setting all the axioms (?) and things like that. Then, you would barely simulate one and take a couple of seconds. One option that you had of sending messages to people and getting other people's information.
- Q-54: *Umm Hmmm. You liked that?*
- A-54: I think that was cool.
- Q-55: *You did? Why?*
- A-55: Because not many programs have that to be used . . . I use my hands a lot . . .
- Q-56: *That's okay.*
- A-56: . . . where you can actually almost like interact with other people in the room without really . . . kind of like Internet, in a way, you know, and . . .
- Q-57: *Umm Hmmm.*
- A-57: . . . you know, like another thing that'd be, you could put it in that, if you could, you know, ask for something or record the question and then record the reply or something like that, or you can . . . and, you know, just . . . I liked that part a lot.
- Q-58: *Okay. Was there anything about it that you didn't like?*
- A-58: Umm . . . not really, besides the lack of brightness and . . . I didn't like the fact that it . . . that it only did one and they were exactly the same when you told them nothing, I think it was . . .
- Q-59: *Right.*
- A-59: You know, it was like too confusing. They should have it . . . have a note there to say, you know, this is the same, or something . . . 'cause it was freaking me out . . . it was like "why is my computer messing up like this" . . . it was like, you know?
- Q-60: *Yeah. That threw us off the loop there.*
- A-60: Right.
- Q-61: *Now, think about your opinion of ELabBook the first time you tried it and then what*

- you thought of it later on. Did it change?*
- A-61: Kind of because at first, I thought it would be something like . . . it was like thinking that the simulations and all that would be like little inky dinky things like that had basically no realness at all but then I tried it and, you know, I was pretty surprised that it was more advanced than I thought. I thought it would be some little dinky program but it turned out to be pretty cool.
- Q-62: *Why did you think it would be that way?*
- A-62: I don't know. It was just like my expectation because it was like "oh oh, this is probably just some little weird little sixth grader program or something" and, you know, just basically, you know, first thought.
- Q-63: *Umm Hmmm.*
- A-63: You know.
- Q-64: *Okay. Did you think it was easy to use?*
- A-64: Yeah. Extremely.
- Q-65: *Okay. Why?*
- A-65: Because it . . . well, you know, there really wasn't much too it, you know, once you . . . unless something like that happens where it gets confusing 'cause that threw my partner and I off because, you know, we ended up not being able to print a couple because we were switching computers and things like that, so (indistinguishable).
- Q-66: *Okay. What did you think about those notes that you were asked to fill in?*
- A-66: I think that was helpful.
- Q-67: *Why?*
- A-67: Because we got to put all our information in, what we found, you know. I think they should have been more explicit, more direct, you know. I can't think of any examples right now but, you know, that are uhh direct.
- Q-68: *Okay. I think I follow you. Now, do you think this program was valuable to you in learning science?*
- A-68: Definitely, it was because, you know, uhh . . . it helped me to think, to understand like uhh understand the second law of thermodynamics better . . .
- Q-69: *Umm Hmmm.*
- A-69: . . . you know, than I would have about it so, it was.
- Q-70: *Is there anything specific that you feel like you learned?*
- A-70: Well, I learned not to . . . you know, I used to think that aluminum foil would be great to keep things warm just because my mom cooked. You know, once you bake potatoes, you put them in aluminum foil and that sounds like "oh, it must keep them warm".
- Q-71: *Umm Hmmm.*
- A-71: And so I figured out that just because you see something like that, you have to go firsthand to find out.
- Q-72: *Okay. Would you want to teach someone else how to use this program?*
- A-72: I don't have no idea.
- Q-73: *No? Why?*
- A-73: Because, you know, it's fairly simple and, you know, it helped me a lot so I'm sure that other . . . it helped other people too so, yeah, it was cool.
- Q-74: *Do you think you could teach them?*
- A-74: I don't think I myself could because I would end up, you know what I mean, (indistinguishable) that stuff.
- Q-75: *All right. That's all the questions I have for you but I want to give you a chance to make a comment on anything we've talked about here or anything we did back there.*
- A-75: Okay . . . (END OF SIDE B OF TAPE 12 AND BEGINNING OF SIDE A OF TAPE 13) Well, I guess that it was cool and, uhh, you know, it's better than the normal

book style that, you know, we would have had to learn that you'd known . . . and uhh  
it was easier to understand than any (indistinguishable), so, you know, . . .  
plus one of my favorite things was that I got to meet Mr. Rubio.

Q-76: (chuckle)

A-76: He's cool.

Q-77: (chuckle)

A-77: And, of course, now he has to go back to UofM.

Q-78: *That's right.*

A-78: He's cool to go up to the high school with us.

Q-79: *Okay. Well, thank you for the editorial. I appreciate it.*

A-79: You're welcome.

Q-80: *Thank you for your interview too.*

A-80: Okay. You're welcome.

- Q-1: *This is Day 3. What I'd like to do to start with is, I'd like to give you some phrases that are written on construction paper here and what I'd like to ask you to do, is to try and make a sentence out of this. Now, you could use all these phrases if you want. You don't have to. You can use some of them. It's not as important how many you use. What's very important is that you make a sentence that you would agree with, or that you think is true, or that you think makes sense to you. There's no time limit, so just take your time.*
- A-1: . . . (long pause) . . . Umm . . . what's the difference between cold energy and cold?
- Q-2: *That's a good question. What would you say? I mean, some people think there's a difference and some people think there isn't.*
- A-2: Like, uhh . . . I don't know.
- Q-3: *Actually what I'll probably do is after you put the sentence together, I'll probably ask you about each of the things you put in, so if you want to think of what you think cold energy is and use it, then we'll end up talking about it afterwards.*
- A-3: . . . (short pause) . . . Hmmm. (Indistinguishable) "ands" or something like that. I need an "and" like, you know.
- Q-4: *I can give you more "ands" and if there's a . . . if you want to use other phrases that aren't there, we can just pretend they're there, if you'd like. Leave an empty spot and we'll just stick that word in there.*
- A-4: . . . (short pause) . . . and the same way get an "are".
- Q-5: *Okay, we can put an "are" there.*
- A-5: Like, when we make one what? Sentence?
- Q-6: *Yeah, just one sentence.*
- A-6: Oh, okay (chuckle).
- Q-7: *Is that it?*
- A-7: Yeah (chuckle).
- Q-8: *Okay, why don't you go ahead and read that?*
- A-8: (chuckle) Heat and cold are temperatures.
- Q-9: *Okay. Now, what is that . . . what is in there that you would agree with?*
- A-9: Uhh, in the sentence?
- Q-10: *Yeah, why did you pick that sentence?*
- A-10: Because uhh like if it's cold outside, you know, it's like a certain temperature; and heat is a temperature too, so.
- Q-11: *Okay. What does "heat" mean to you?*
- A-11: Well, it could be warm or hot -- you know, heat.
- Q-12: *Okay, and what about "cold"?*
- A-12: Same thing, you know (chuckle).
- Q-13: *Okay, and what about temperature?*
- A-13: It's like the measure on how hot or cold it is.
- Q-14: *Okay. I'm going to ask you about another word here and that's this word -- "heat energy". What do you think that means?*
- A-14: Well . . .
- Q-15: *Do you think it's the same . . . it means the same as heat?*
- A-15: What is the energy in the heat? I don't know.
- Q-16: *I'm curious what you're interested in, so. Yeah just, you know, I'm not looking for like a right answer or anything so just tell me what you think.*
- A-16: Uhh, I guess it's mainly . . . I don't know, I guess it's the energy in the heat (chuckle).

- Q-17: *Okay. Okay. Do you have like a situation in your head or a picture of something going on in your head behind this right here?*
- A-17: (chuckle)
- Q-18: *Could you think of something maybe that would illustrate this thing here?*
- A-18: I guess I could think of a like a thermometer or something, I don't know.
- Q-19: *Okay and how would a thermometer illustrate this?*
- A-19: Well, you could . . . not a thermometer but a . . . yeah, I think it's a thermometer to measure like, you know, any thermometer?
- Q-20: *To do . . . to measure?*
- A-20: You know, so you can look on the thermometer and see how hot it is or whatever??
- Q-21: *Umm Hmmm. Yes.*
- A-21: Yeah . . . Umm . . . you can look at the thermometer and see, uhh, how hot or cold it is?
- Q-22: *Okay. Okay. That's all for that.*
- Q-23: *On this next part, what I'm going to do is, I'm going to ask you a question and a couple of follow-ups. The question is, do containers or wraps that are good for keeping hot objects hot, are they also good for keeping cold objects cold?***
- A-23: Umm. Umm, I guess so (chuckle). Like if . . . if like a thermometer . . . not a thermometer, I'm a little confused. . . a container holds in heat, I guess it could hold in like . . . I don't know, like when you open a freezer or something and you got like the air coming out or whatever, so I guess it could hold that in too.
- Q-24: *Okay.*
- A-24: Or maybe not (chuckle) (Transcription note: Sounds like a sigh)
- Q-25: *Well, can you think of some . . . some containers or some materials that might work for both or might not work for both?*
- A-25: Like uhh . . . I don't know if there's so many cold but I know a lot of stuff that can hold in heat, like a Tupperware or something.
- Q-26: *Okay. Tupperware.*
- A-26: There's foil.
- Q-27: *Okay, aluminum foil. Do you . . . have you seen these used for that before?*
- A-27: Yeah.
- Q-28: *All right. Like where?*
- A-28: Like uhh, if you cook something you uhh put like . . . say you got some chile or something, you put like some foil over it or put it in Tupperware or a thing, or you can use windows wrap (chuckle).
- Q-29: *Okay. Now, what about for keeping something cold? Could you use those same materials to keep something cold or not?*
- A-29: Uhh. I don't know. Maybe Styrofoam. You could use it for something cold.
- Q-30: *Okay. What do you think would . . . how do you think you can tell whether something does a good job or doesn't do a good job at keeping something hot or cold?*
- A-30: I guess you have to see the results.
- Q-31: *So, how do "you" figure out when you're looking for something?*
- A-31: Uhh . . . I don't know. I guess if uhh you try it out, test it out.
- Q-32: *Okay. You talked about Styrofoam. Would you say that's something that could be used for both or just for one?*
- A-32: Yeah.
- Q-33: *For both?*
- A-33: Umm Hmmm.
- Q-34: *Okay. Why would you say that?*
- A-34: Well . . . because like . . . it is . . . I don't know . . . I really don't.
- Q-35: *Okay. All right. That's fine.*

- Q-36: *Let's talk about computers now, okay? Think about that ELabBook Program. Do you remember that?*
- A-36: Uhh . . . I don't really know about it.
- Q-37: *That's okay. You did work on it a little though.*
- A-37: A little (chuckle)
- Q-38: *What did you think about it?*
- A-38: I didn't really work on it enough to, you know, to really know.
- Q-39: *Okay. From what like your friends maybe talked about it . . . did any of your friends talk about it at all?*
- A-39: Uhh Uhh.
- Q-40: *Okay. Have you ever used a lot of educational programs before?*
- A-40: On computer?
- Q-41: *Umm Hmmm.*
- A-41: No, I really like never use a computer . . . I mean, I use a computer sometimes, like whenever I'm over at my cousin's house, but I never really use the computer. Well, like at school or something like that, we play games on it. But like at school, we uhh do stuff like that, but like ELabBook . . .
- Q-42: *Umm Hmmm.*
- A-42: No not really.
- Q-43: *From what little you saw of it, how would you compare it to a game?*
- A-43: I guess it's something like a game because like you got a . . . like well, what I (indistinguishable) when you had the potato and stuff like that, what I (indistinguishable) like, is you had to type in a little stuff or whatever.
- Q-44: *Umm Hmmm.*
- A-44: Well, I guess it'd be something like a game.
- Q-45: *What did you think about having to do all that stuff?*
- A-45: Well, I didn't think nothing of it.
- Q-46: *Didn't like it or dislike it.*
- A-46: No, I didn't.
- Q-47: *Okay. Let's see. Is there . . . now, these are probably about all the questions that I wanted to ask. I was wondering. Is there any comment you wanted to make about anything we've talked about here or anything that happened before?*
- A-47: Uhh, no . . . but like what is this for . . . this?
- Q-48: *This is . . . what I'm doing is I'm looking and seeing how kids learn about science and how they learn about science using the computers, and what just kind of how computers help them learn. Does it help them just think about stuff, does it also get them excited about doing it, just exactly how do they work.*
- A-48: Umm Hmmm.
- Q-49: *So that's what I'm doing. I'm talking to people, talking to you all.*
- A-49: Well, I guess uhh some kids were like, you know, saying "well, like I'm not really here a lot so, you know, I don't really work on the computers a lot anyway so I guess other people, other kids, would find it fun.
- Q-50: *Umm Hmmm. Okay. All right. That's it. Thank you.*
- A-50: Umm Hmmm.



- Q-1: *This is Day 3. All right. What I'd like to do is, I'd like to give you some phrases here on construction paper and what I'd like to ask you to do is to put these phrases together so that they can form some kind of a sentence. Now, you can use some of these phrases or you can use all of them. It's up to you. It's not as important how many phrases you use but what is important is that you make a sentence that says something that you believe to be true, or something that makes sense to you, or something that you agree with. Take your time.*
- A-1: . . . (very long pause) . . .
- Q-2: *Got it?*
- A-2: *Yep.*
- Q-3: *Okay. Go ahead. Why don't you go ahead and read it?*
- A-3: *Objects at higher heat temperature stays in heat energy.*
- Q-4: *Okay. Now, can you tell me what it is about this that would make you think . . . or that makes sense to you?*
- A-4: *That like objects that has heat temperature stays in heat energy.*
- Q-5: *Have you seen something or experienced something that makes you think this is true?*
- A-5: *Uhh . . . probably, some food, like when it's hot, like the heat stays with the heat and it doesn't travel off. It just . . . the air cools it so . . . like if we have some food, the heat temperature stays in the energy.*
- Q-6: *Umm Hmmm. Okay. Now, I want to ask you just what some of these terms mean to you. What does this term here -- heat energy -- mean to you?*
- A-6: *The energy heat gives off -- the energy.*
- Q-7: *Okay, and what is that energy?*
- A-7: *The energy is like heat or . . . or the sun heat sometimes can give energy like light. It can give off light.*
- Q-8: *Okay. What about this here -- heat temperature? What's that?*
- A-8: *That's like heat that's hot . . . heat . . . like it's . . . like a temperature of heat.*
- Q-9: *Umm Hmmm.*
- A-9: *You get like the heat as of a certain temperature.*
- Q-10: *Okay. What do you normally think of as that temperature?*
- A-10: *Uhh . . . well, 70 degrees.*
- Q-11: *Okay. What do you think is the difference . . . or do you see a difference between heat temperature and heat energy?*
- A-11: *Nope.*
- Q-12: *You think they're kind of the same?*
- A-12: *Yeah.*
- Q-13: *Okay. What do you mean when it says "stays in"?*
- A-13: *Like it doesn't travel, it just stays in there.*
- Q-14: *Okay. Is there a reason why it stays in there?*
- A-14: *Uhh . . . 'cuz heat doesn't travel. Heat . . . the only time heat rises is if there's like fire but if it's just like in a object, like food, heat with an object, it will stay until it cools off.*
- Q-15: *Umm Hmmm. Okay. Okay. Well, that's all for that part.*
- Q-16: *I'm going to ask you a different question now and a couple of follow-ups probably. Now, if I have a container or a wrap or a material and it's good for keeping hot*

*objects hot, would that same wrap or material also be good for keeping cold objects cold?*

- A-16: Yeah, 'cuz no heat would be able to get to the cold to cool it off. It would stay cold.
- Q-17: *Umm Hmmm. Can you think of specific objects or specific materials that would do that?*
- A-17: Uhh . . . a refrigerator, a freezer . . . it keeps the cold air inside it and the door is kind of like the wrap.
- Q-18: *Umm Hmmm. In what way?*
- A-18: 'Cuz when you close the door, it seals it and makes the (indistinguishable) higher on the inside to cool it off.
- Q-19: *Okay. Do you think there are containers or wraps that are good for keeping things hot but aren't good for keeping thing cold?*
- A-19: . . . Uhh . . . no.
- Q-20: *Why not?*
- A-20: Well, yeah 'cuz some things absorb heat and if they absorb heat, it'll give off heat to whatever you're trying to cover up. If you have some ice in a box and you have something put over it, something that absorbs heat, it could, the ice could melt quicker.
- Q-21: *Okay. Can you think of what that something might be? Do you have something in mind?*
- A-21: Uhh . . . I don't know. It should be something that would absorb heat though. Probably a metal.
- Q-22: *A metal? Why would a metal be able to do that?*
- A-22: 'Cuz metal, it gets hotter. It'll absorb heat more.
- Q-23: *Okay.*
- Q-24: *Let's talk about computers now. Think about that ELabBook Program that we did. Do you remember that?*
- A-24: Yeah.
- Q-25: *Okay. I'm going to show you a scale and I'd like for you to rank ELabBook on this scale against all the other computer programs that you've used before.*
- A-25: . . . (short pause) . . . I'll rank it like this one.
- Q-26: *Okay. Would you read that one?*
- A-26: It was okay but I've never used anything I've really liked.
- Q-27: *Okay. Now, why did you pick that one?*
- A-27: 'Cuz I say it's okay.
- Q-28: *Umm Hmmm.*
- A-28: But most of the programs, I don't judge the programs.
- Q-29: *I'm sorry, you don't what?*
- A-29: I don't judge the programs.
- Q-30: *Okay. Were there things you liked about ELabBook?*
- A-30: Umm, yeah.
- Q-31: *Could you tell me some of them?*
- A-31: Like the one thing where you type in something and you could make it talk.
- Q-32: *Umm Hmmm.*
- A-32: That was . . . I liked that.
- Q-33: *What did you like about that?*
- A-33: 'Cuz you could type in anything and make the computer say it.
- Q-34: *Umm Hmmm. Okay. What else?*
- A-34: That's mostly it.
- Q-35: *Okay. Were there any things about ELabBook that you didn't like?*
- A-35: Umm . . . no.

- Q-36: *Now, think about when you first started using ELabBook, like the first day or so, and your opinion of it, and then your opinion of it after you used it for a while. Did your opinion change any as time went along?*
- A-36: It pretty much stayed the same.
- Q-37: *Okay. Okay, and did you think that ELabBook was easy to use?*
- A-37: Uhh . . . once you got the hang of it, it was easy.
- Q-38: *How long did it take you to get the hang of it?*
- A-38: Probably the second day.
- Q-39: *Okay. What did you think about those notes that you had to fill in. Do you remember those notes?*
- A-39: That was . . . those were pretty tough but we finished all of them.
- Q-40: *Okay. How . . . why were they tough?*
- A-40: 'Cuz you had to . . . uhh, think of the answer for what we got asked . . . we got asked to answer like questions about "when have you ever used heat energy" and stuff and it asked all those questions.
- Q-41: *Umm Hmmm. Even though it was . . . did you enjoy answering those questions?*
- A-41: Yeah.
- Q-42: *Now, do you think this program was of value to you in learning science?*
- A-42: Uhh . . . yeah.
- Q-43: *In what way?*
- A-43: It taught us more stuff about heat energy and stuff.
- Q-44: *Okay. Can you think of something specific that you learned from using it?*
- A-44: Uhh. I could use about . . . I learned about the coke bottles where you wrap it and stuff.
- Q-45: *Umm Hmmm.*
- A-45: We wrapped the potato (indistinguishable) and we learned about that.
- Q-46: *What did you learn about it?*
- A-46: I learned the different materials you can use for wrapping it and will it keep the heat or the coolness inside it.
- Q-47: *Okay. Would you want to teach someone else how to use this program?*
- A-47: Uhh . . . if they wanted to know about it, I'd teach them.
- Q-48: *Okay. Do you think "you" could teach them?*
- A-48: Uhh . . . yeah.
- Q-49: *Well, that's all the questions I have. What I'd like to do is to give you a chance to make a comment on anything we've talked about here or anything that happened back over there.*
- A-49: Uhh. It was pretty fun, using the computers.
- Q-50: *Why do you say that?*
- A-50: Because the only time they use computers at school is if you have computers . . . if you have the computer class but I don't have a computer class, so it was fun using it. I have one at home . . .
- Q-51: *Umm Hmmm.*
- A-51: . . . but I don't play that one too often.
- Q-52: *Why not?*
- A-52: 'Cuz the games . . . I already played all the games.
- Q-53: *Oh, okay (chuckle), so it was kind of new to be able to . . . why did you call this "fun" over here?*
- A-53: 'Cuz it was a different kind of computer than an IBM. A Macintosh Computer is a whole lot different.
- Q-54: *Umm Hmmm. Okay. Is that all?*
- A-54: Umm. Yeah.
- Q-55: *Okay. That's all. Thank you very much.*
- A-55: You're welcome.

- Q-1: This is Day 3. Okay, to start with, and you said you recognized these from the last time, I've got these little phrases on construction paper and what I'd like for you to do is to make a sentence out of this.
- A-1: Okay. Just like the principle . . . from the computer?
- Q-2: *Umm Hmmm. That's right. Just to remind you. You don't have to use them all. You can, if you want to. It's not as important how many you use. What is important is that what you come up with is something that you think is true.*
- A-2: . . . (short pause) . . . Hmmm. Let's see if I can come up with this . . . (long pause)  
You don't have something that says "out of"?
- Q-3: *If you want to put something that says "out of" . . .*
- A-3: . . . or "from" . . .
- Q-4: . . . you can just pretend it's in there.
- A-4: Do you have the word "from" or something?
- Q-5: *Let me see, I don't think I have a "from" . . . and if you need an "out of", you can just pretend there is an "out of" and you can just leave a blank spot or something . . . Here's an "out of".*
- A-5: You don't have a "from"? (Indistinguishable)
- Q-6: *No, I don't have a "from". Like I said, we can just pretend there is a "from" in there. Oh, here's the "out of".*
- A-6: Uhh Huh . . . flows . . . flows . . . flows . . . and you want it . . . let's see, I want it to say "flows" . . . "flows from" . . .
- Q-7: *Okay. Maybe you should leave an empty spot there so that you'll know that there's something that has to go in there.*
- A-7: . . . (short pause) . . . I don't know. I want to say "heat energy flows from hotter to colder".
- Q-8: *Okay, if you want to go with that, that's fine.*
- A-8: But you don't have that, man . . . wait . . . (sounds as though person speaking is thinking aloud) . . . heat energy flows into colder objects (chuckle) or . . . (long pause) . . . Hmmm . . . well, let's stick within the principle. First of all, (rest of sentence is indistinguishable).
- Q-9: *Perhaps you want to go with that one you said earlier. That would be okay.*
- A-9: Hmmm. Well, that's what . . . I'd like to say.
- Q-10: *Okay. Well, if you'd like to say that, that's . . .* (Transcription Note: The rest of this sentence is interrupted by the following response).
- A-10: And you know what I have to say, kinda like. (Transcription Note: Sounds like fingers snapping and someone thumping on the table are heard in the background)
- Q-11: *What did you do right there?*
- A-11: I just . . . I really . . . There's no place to put my energy so I'll just get it out because I'm confused about it. (The rest of the sentence is indistinguishable.)
- Q-12: *I just said that so the tape would . . .*
- A-12: Uhh Huh.
- Q-13: . . . Okay.
- A-13: I want to say that. Heat flows into cold objects or heat . . . heat energy . . . (END OF SIDE A AND START OF SIDE B OF TAPE 13) Nothing flows into other objects from cold or hot to colder unless this flows out . . . no . . . it flows into colder objects . . . heat energy flows out of hotter objects (indistinguishable) . . . it's colder objects (Transcription Note: Loud ticking and adult voices are heard in the background) . . . okay, I'll just go with this sentence: Objects at higher temperatures . . . tempera-

- ture . . . comma . . . energy flows out of . . . oh, man (chuckle) . . . heat energy, no that's not . . . cold . . . I can't say it (laughter) . . . Umm, that would be okay . . . there are some (indistinguishable) give us some words. Objects at higher temperatures comma . . . wait . . . objects at higher temperatures comma heat energy flows into cold objects. (The next sentence is indistinguishable.) . . . (long pause) Whew . . . (Transcription Note: Loud thumping sound heard in the background) . . . Turn off the (Transcription Note: Sounds like "air".)
- Q-14: *Okay. If you want to go with that, go ahead.*
- A-14: Heat energy flows into the cold objects.
- Q-15: *Okay.*
- A-15: . . . No, flows . . . I want to say "from". Heat energy flows from cold objects . . . not "from" . . . bummer, bummer . . . higher . . . from . . . (long pause) . . . Hmmm . . . Hmmm . . . (long pause) . . .
- Q-16: *You know, I'm going to say that because you keep going back to that, why don't we just go with that. Is that okay?*
- A-16: Yeah.
- Q-17: *So, read it one more time.*
- A-17: Heat energy flows into colder objects.
- Q-18: *Okay. Now, tell me what it is about that, that you find to be true?*
- A-18: Umm. The law of thermodynamics (Transcription Note: The same thumping sounds continue in the background.)
- Q-19: *Umm Hmmm.*
- A-19: Thermodynamics where the heat always travels from your warmer objects to the cooler objects and then from there into warmer until you get it to equal (indistinguishable) they all have the same temperature.
- Q-20: *Okay. Now, let me ask you a couple of things. What does this term here -- heat energy -- mean to you?*
- A-20: Just heat. Same as heat . . . the same.
- Q-21: *Okay. So you're saying this is the same as heat?*
- A-21: Umm Hmmm.
- Q-22: *How would you describe that to somebody?*
- A-22: I'd say they're the same -- heat and heat energy.
- Q-23: *Okay. So how would you still describe these to somebody?*
- A-23: Heat energy?
- Q-24: *Umm Hmmm. Or heat.*
- A-24: Uhh. I'd describe "heat" -- what it means, you know, heat -- and "heat energy" . . . probably energy or the things it does, like how the molecules are . . . Hmmm . . . heat energy . . . rays from the sun. I'd call that heat energy. (Transcription Note: The next sentence is indistinguishable. The last part sounds like: same as sound.)
- Q-25: *Okay. What about this idea of "energy flow"? What is that supposed to mean?*
- A-25: Heat energy flows?
- Q-26: *Umm Hmmm.*
- A-26: It . . . uhh . . . It's like the heat energy or heat flows, like goes through or . . . dusty (Transcription Note: One thumping sound is heard immediately after this word) . . . it's sort of like it flows when the molecules are released. When the heat moves, they go faster and just hit each other both . . . flows . . . that's exactly what it means (chuckle).
- Q-27: *Okay. What about this word down here -- temperature? What does that mean to you?*
- A-27: It tells how hot or how cold something is.
- Q-28: *Okay.*
- A-28: (Indistinguishable)
- Q-29: *Okay. Do you have a picture or an illustration in your mind as you were making this, or do you have one right now about it?*

- A-29: Yeah, I have one.
- Q-30: *What is it?*
- A-30: Uhh . . . let's see, basically what we worked on, how an insulator can slow down the heat energy, from the inside to the outside to the . . . from inside in the can to the insulation to the outside aluminum to the water to try and slow it down . . . that's what.
- Q-31: *Umm Hmmm. Okay. Okay. Well, that's all for that part.*
- Q-32: *What I'd like to do now is, I'd like to ask you another question and then maybe do a couple of follow-ups on that.*
- A-32: Umm Hmmm.
- Q-33: *The question is, do containers or wraps that help keep hot objects hot also keep cold objects cold?*
- A-33: Yes.
- Q-34: *Why would you say that?*
- A-34: 'Cuz . . . Umm . . . it does the same thing. A good insulator would . . . if you had it like for instance the project we just got finished doing, with the water inside, it's like you have to keep the heat inside to keep the cold from coming . . . you know, keep the . . . as much as . . . slow the heat down from going to the cold . . . you know, coming out and getting cooler and, at the same time, it stopped the colder from getting in and making it . . . I mean . . . well, you know, stopped . . . (indistinguishable) come back . . . they stopped the heat both ways . . . like heat just slowed it down . . . it stopped the heat from coming in and if it was cold water in there and hot water on the outside, it would stop the heat from coming in both ways, so.
- Q-35: *Okay. Now, can you think of specific containers or materials or wraps that do that?*
- A-35: Specific . . . Styrofoam?
- Q-36: *Okay. Styrofoam. Now, what is it about Styrofoam that allows it to do that?*
- A-36: I haven't looked at what this is doing on the computer but on some of the experiments we did, the best ones were wool and Styrofoam . . . and like the Styrofoam coolers, I think that'd probably work well to keep your Coors(?) and your pops and everything cold.
- Q-37: *Okay. Is there . . . would there be a container or wrap that would work for one way and not for the other . . . in other words, that would keep something hot but not keep something cold?*
- A-37: No. I don't believe so.
- Q-38: *Okay. How would you be able to tell how well something does at keeping something hot versus keeping it cool?*
- A-38: How would I do it myself? I'd have to experiment.
- Q-39: *Okay. How would you do that?*
- A-39: Uhh, I'd take my material and somewhat similar to what we did, probably if I'd having to cook something or whatever and I wanted to keep it hot, I'd probably use up the new material just to experiment and if it did, I'd come back to it after so much . . . so long and if it's still nice and warm or not, I'd know. Then, I'd probably try something cold, wrap it up and try to keep it cold, set it out at room temperature or whatever and if it keeps cold, then . . . that's how I would experiment.
- Q-40: *Okay. Do you do stuff like that?*
- A-40: Umm Hmmm. All the time.
- Q-41: *Okay. All right, that's all for that.*
- Q-42: *Let's talk about computers now.*
- A-42: Umm Hmmm.
- Q-43: *Think about the ELabBook Program that you used in class. Do you remember that?*
- A-43: Umm Hmmm.

- Q-44: *Okay. I'm going to show you a scale and what I'd like for you to do is rank ELab-Book on this scale in comparison to all the other computer programs you've used before.*
- A-44: What scale? This is not a scale.
- Q-45: *Yeah. Well, this is sort of a scale. There's four different items.*
- A-45: By far the best I've used . . . as material?
- Q-46: *As a soft . . . as a program.*
- A-46: Oh.
- Q-47: *As a program -- ELabBook.*
- A-47: (Transcription Note: Appears to be reading) "I picked this as the best but I think about others. That was okay but I've never used anything I really . . . never used anything I really liked. This is the only one I've ever used." As a software program? . . . (short pause) . . . none of these.
- Q-48: *Okay, then make up one.*
- A-48: Umm . . . it was okay but I liked other ones better.
- Q-49: *Okay.*
- A-49: Yeah.
- Q-50: *Now, why would you say that about ELabBook?*
- A-50: Well, because I worked with . . . it's like that was more educational and experiments and I like experiments. That was, you know, that was okay to use for the time but then there's other programs I like better. It's just . . . one thing I like about computers is drawing or changing pictures from one thing to another and making it look good and stuff like that more than just typing, you know, than the other programs are like.
- Q-51: *Okay.*
- A-51: On the computer . . .
- Q-52: *Okay. Now, so it's the function of those other programs or is it the way the other programs are put together that makes them . . . makes you like them better?*
- A-52: Well just . . . I don't know . . . just 'cuz it's educational. The ones . . . the other ones . . . you see, that was nice and educational but that's not something, if I had a computer at home, that's not nothing I felt like I could do a lot of time. Now, something else, like a drawing program, it's fun and not as educational and it doesn't take as long to put things together. I like that better. It's just too educational. It was fun but it was too educational. It's sort of like if you could be doing school or going to the flea market, I'd pick the flea market. It's sort of like that.
- Q-53: *Hmmm. Interesting. Okay. Now, given that, were there some things you liked about ELabBook?*
- A-53: Umm Hmmm. That was interesting how . . . uhh, you can do the uhh. . . you know, test the different materials and do . . . you know, to just . . . testing the materials on keeping an object hot or cold. With the computer, it was a lot quicker than doing it in "real time" like, I mean, you know, doing it yourself. Getting the material and everything is a lot cheaper and I think that was . . . I liked that. It was interesting.
- Q-54: *Okay. Was there anything else you liked about it?*
- A-54: Uhh . . . The other thing I liked about it was the principle of choosing the materials.
- Q-55: *Why did you like those things?*
- A-55: 'Cuz it's umm . . . it . . . okay how to choose different material is like . . . I like kind of to decide which material . . . I choose the material that I think or I know will work and then choose the material that I'm not sure about or that I'm not sure will work. Between you and I, I think I might because I didn't choose any materials that I knew wouldn't work. I thought foil worked. I choose that once. Foil and wool but foil wouldn't work. Foil did nothing, I think, or something. But I wouldn't choose nothing like saran wrap because I knew that wouldn't work so I wouldn't want to find it out. But I like to compare them and find out between them and see

- which one works the best, 'cuz I know probably this one works well, this one works well but which one works better.
- Q-56: *Okay. Now, the other thing that you mentioned was the principle.*
- A-56: Uhh Huh. I like trying to find out what was the principle. I enjoyed it really.
- Q-57: *Okay. Were there some things that you didn't like about ELabBook?*
- A-57: How long it took. Why when you put . . . if it's uhh. . . how long it took for instance when you went into all the vari . . . you know everything about the potato, the temperature and everything, how long it took to get, uhh, put that information in it, well when you want some . . . when you go to the checklist or choose something else, you could wonder how long it takes for the button to pop up when you lay down the button, when you lay down the button, how long it takes. It takes a long time for it to happen.
- Q-58: *Hmmm. Okay. Did you think that was the program or the computer?*
- A-58: The computer.
- Q-59: *You thought that was the computer.*
- A-59: Umm Hmmm.
- Q-60: *Okay. Now, think about your opinion of ELabBook when you first started using it and then your opinion after you'd used it for a while, did it change over time or did it stay the same.*
- A-60: It stayed about the same.
- Q-61: *Did it?*
- A-61: Well, I don't know. I enjoy computers a lot, you know. Just about anything I'm going to . . . anything on a computer is interesting and I like to do and when you're concentrating on the ELab program that I've probably never used, I'd probably be eager to use it even though I never used it. (Indistinguishable) first couple of hours and then it changed. In fact, it got better (chuckle).
- Q-62: (chuckle) *Okay. Okay. Did you think ELabBook was easy to use?*
- A-62: Oh, very easy.
- Q-63: *Did you?*
- A-63: Umm Hmmm.
- Q-64: *What especially made it easy?*
- A-64: Uhh, mainly it was just clicking the mouse and when it asked us the questions, all you gotta do was read what you have, and then just write down what you have and explain in detail what happened, so.
- Q-65: *Okay. What did you think about those notes that you were asked to fill in? Did you?*
- A-65: They were simple . . . pretty simple. You just mark it down.
- Q-66: *Okay. Do you think this program was valuable to you in learning science?*
- A-66: Yes.
- Q-67: *In what way?*
- A-67: Umm . . . well, it's like you say . . . why do you go to me in learning something? Did I learn anything of it? Well, yeah, I learned a few things between the materials, like which materials work and which don't but other than that, most things I knew in the computer and a lot of the stuff ELab had, I knew, but material wise -- what worked and what doesn't -- some things I didn't.
- Q-68: *Okay.*
- A-68: I never knew wool worked that well.
- Q-69: *Oh, yeah.*
- A-69: Umm Umm. I thought that . . . I thought that was just a far way down.
- Q-70: (chuckle) *That's good. Now, would you want to teach someone else how to use this program?*
- A-70: Yeah.
- Q-71: *Why?*
- A-71: 'Cuz I thought it was interesting and nice for them to learn, uhh, how . . . you know, for them to at least use their mind. They will remember the law of thermo-



dynamics and the terms and everything and try making up principles and ask them questions by reading the (indistinguishable).

Q-72: *Okay. Do you think "you" could teach them?*

A-72: *Umm Hmmm.*

Q-73: *Okay. Now, that's all the questions I have. What I wanted to do now is give you an opportunity to comment on anything we've talked about here or anything that we did back over there.*

A-73: *No comments.*

Q-74: *No comments. Okay. That's all. Thank you very much.*

A-74: *Okay.*

- Q-1: *This is Day 4. All right. I'm going to name three different materials and I'd like for you to tell me if you would use them, each material, for keeping something hot, for keeping something cold, for doing both or for doing neither. Okay?*
- A-1: All right.
- Q-2: *The first material is aluminum foil.*
- A-2: Cold.
- Q-3: *Okay, why do you say that?*
- A-3: Because I done it before, with pop, and it kept it cold for the day.
- Q-4: *Where did you do it at?*
- A-4: Well, when I went on a field trip.
- Q-5: *And how did it work?*
- A-5: Very. It kept it cold.
- Q-6: *Did it? About how long?*
- A-6: Uhh . . . hour.
- Q-7: *Okay. Why wouldn't you use aluminum foil for keeping something hot?*
- A-7: It's just not a good one.
- Q-8: *Why not?*
- A-8: Because we did it on that experiment and it didn't work out very well.
- Q-9: *Which experiment?*
- A-9: When you use the probes.
- Q-10: *Umm Hmm.*
- A-10: I got 34.6. That's not very good.
- Q-11: *What do you mean, you got 34.6?*
- A-11: We didn't do it. The other team and they used the probes and they only used a piece of aluminum foil and got 34.6.
- Q-12: *Okay, and you didn't think that was very good?*
- A-12: No.
- Q-13: *Okay. Let's try another material. How about wool?*
- A-13: Hot.
- Q-14: *Okay, now why do you say that?*
- A-14: 'Cuz it's a good insulator.
- Q-15: *What do you mean by a good insulator?*
- A-15: It keeps stuff hot, or warm, because we tried it out in our experiment.
- Q-16: *What did you do?*
- A-16: We wrapped it around a soup can and it kept it 8.9.
- Q-17: *Now, why would you not use wool to keep something cold?*
- A-17: Because it's real thick and it keeps stuff hot. It's a real thick material.
- Q-18: *The last material is Styrofoam.*
- A-18: Ohh . . . both.
- Q-19: *Okay, why do you say that?*
- A-19: 'Cuz it'll keep it cold or warm. It depends on however you might want to use it.
- Q-20: *And how do you know that it can be used both ways?*
- A-20: 'Cuz I've done it both ways.
- Q-21: *When did you do that?*
- A-21: I did . . . I did it for a science project and (indistinguishable) we use Styrofoam all the time.
- Q-22: *And what did you do with it?*
- A-22: Just put one on a (indistinguishable) and it worked.

- Q-23: *Okay. How did you know it worked?*  
A-23: *'Cuz it was still warm when I went back to it about a hour and a half later to two hours and it was still cold.*
- Q-24: *Okay. Now, let me ask you this. How can you tell what makes something a good insulator? You talked about an insulator.*  
A-24: *Just by the way it works. You can just look at it and tell if it'd be a good one.*
- Q-25: *Okay. Is that how you tell? You look at something?*  
A-25: *Yeah.*
- Q-26: *When you look at it, what do you look for?*  
A-26: *It's thickness and what it's made of.*
- Q-27: *Okay. How does what it's made of make a difference?*  
A-27: *Just by the material, you know? Like wool is real thick and you just know it would be . . . get a little hot.*
- Q-28: *Okay. That's all I want to ask you for that.*
- Q-29: *The next thing I want to do is, I want to show you some phrases here that I've got written on construction paper -- let me see, let me move this over here -- and what I've got is . . . I've got these phrases. What I'd like for you to do is to put these . . . arrange these phrases into a sentence. Now, you don't have to use all the phrases but you can if you want to. But what's really important is that you make a sentence that makes sense to you, or something that you would agree with, or something that you believe to be true. Go ahead and take your time and go ahead, go for it.*
- A-29: *Oh no . . . let's see . . . (long pause) . . . this is a little hard one like the one on the computer.*
- Q-30: *It's like the one on the computer.*  
A-30: *It's hard . . . (short pause) . . . I need help on this one.*
- Q-31: *Well, I'm interested in what you think so I won't be able to help you but I can tell you that if you see some words that you'd like to use that aren't on there, we can leave an empty spot and put that word in.*
- A-31: *. . . (short pause) . . . I have to figure this one out.*
- Q-32: *Well, you see the idea there. Is there something you just want to say in your own words?*  
A-32: *Well, I forgot what it was . . . (indistinguishable) I forgot what they were on the computer.*
- Q-33: *Oh that's okay. Don't worry about doing exactly what the computer had. Just tell me what you think?*
- A-33: *. . . (short pause) . . . I don't know.*
- Q-34: *That's okay. Like I said, just try and come up with something in your own words.*  
A-34: *I can't remember what they were on the computer like when I was writing on that ELab thing.*
- Q-35: *Umm Hmmm.*  
A-35: *I forgot what they were. I know it was "heat energy something all at the same pace or something".*
- Q-36: *Well, like I said, don't try to . . . don't try to do what the computer had. Just tell me what you might know about heat energy or one of those other things.*
- A-36: *I can't do it.*
- Q-37: *Stuck, eh?*  
A-37: *Yeah.*
- Q-38: *Okay. Well, we'll go ahead and go on then. Let's talk about computers. Well, actually before we do that, let me just ask you a couple of these. What does this term here mean to you -- heat energy?*  
A-38: *Heat energy? Like energy that heat gives off.*
- Q-39: *Okay. What about this one here -- temperature?*

- A-39: When you take the temperature of something.
- Q-40: *Okay. What is that. What is a temperature?*
- A-40: Like degrees.
- Q-41: *Okay. What about this word here -- heat?*
- A-41: Heat? Hot stuff.
- Q-42: *Are these two the same or different -- heat and heat energy?*
- A-42: Uhh, the same.
- Q-43: *Okay. Okay. That's it for that.*
- Q-44: **Let's talk about computers now. Do you remember the ELabBook Program?**
- A-44: Yeah.
- Q-45: *I'm going to show you a scale and what I'd like for you to do is to rank ELabBook on this scale against all the other computer programs you've ever used.*
- A-45: (Inaudible)
- Q-46: *Could you read that one?*
- A-46: It was okay but I've used anything I've lately . . . but I've never used anything I really liked.
- Q-47: *Okay. Why did you pick that one?*
- A-47: Because that was the way I am. chuckle)
- Q-48: (chuckle) *Well, I mean, did you . . . what did you think of ELabBook then?*
- A-48: It wasn't the best because there's a lot better. It was slow.
- Q-49: *Okay, go ahead and tell me what you think could have been better about it.*
- A-49: It could have been a lot faster and it could have put some more stuff in it.
- Q-50: *Okay. Like what other stuff would you have liked to see in it?*
- A-50: Well. Just make it better. Put color into it and stuff.
- Q-51: *Okay. Put color into it. You said, make it faster? You know, what other things would have made it better?*
- A-51: That's about it. It's a educational program so.
- Q-52: *So what does that mean?*
- A-52: You can't say much about that.
- Q-53: *Oh really, why do you say that?*
- A-53: Because you learn something about what stuff can do on that so . . .
- Q-54: *Go ahead.*
- A-54: That's it.
- Q-55: *So it 's sort of a different kind of program?*
- A-55: Yeah.
- Q-56: *Than . . . than?*
- A-56: You can't change a lot of it because it's a educational program.
- Q-57: *Well, some things you might could change -- the way it looks maybe.*
- A-57: Yeah.
- Q-58: *Were there any other things . . . anything you liked about it?*
- A-58: When we did the probes and saw the temperature and everything. I liked that.
- Q-59: *Why did you like that?*
- A-59: I just thought it was neat.
- Q-60: *Any reason?*
- A-60: No.
- Q-61: *Anything else you liked about it?*
- A-61: That's about it.
- Q-62: *Okay, now, think back to when you first started to use it and your opinion of it when you first started to use it . . .*
- A-62: Stupid.
- Q-63: . . . *And then your opinion of it after a while.*
- A-63: It's okay now.

- Q-64: *Okay, so you thought it was stupid at first . . . ?*  
A-64: *'Cuz I got the hang of it.*  
Q-65: *Why did you think it was stupid at first?*  
A-65: *'Cuz I didn't know how to do nothing. Everything was hard.*  
Q-66: *Was there anything in particular that was hard?*  
A-66: *Just getting through it.*  
Q-67: *Was it clicking the buttons or was it figuring out the logic or was it filling out the notes . . . ?*  
A-67: *It was just the questions they gave you.*  
Q-68: *The questions? Okay. What did you think about filling in those notes?*  
A-68: *Boring.*  
Q-69: *Why did you say that?*  
A-69: *'Cuz you just type and type and type.*  
Q-70: *Was that . . . did you feel pretty much the same way all the way through, that that was boring?*  
A-70: *Yeah.*  
Q-71: *Okay. Did you think it was easy to use at all . . . after . . . once you got the hang of it, that is?*  
A-71: *Yes, it was easy and I can do it in less than one half hour -- a whole program.*  
Q-72: *Okay. Now, do you think this program was valuable to you in learning science?*  
A-72: *Yeah. I can see if you need to keep something warm or cold, you could do it.*  
Q-73: *Okay. Would you want to teach someone else how to use this program?*  
A-73: *Not really.*  
Q-74: *Why not?*  
A-74: *'Cuz they can learn just like I did. (chuckle)*  
Q-75: *(chuckle) But do you think that if somebody asked you, do you think "you" could teach them?*  
A-75: *Probably.*  
Q-76: *Okay. Well, that's all the questions I have. What I wanted to do was give you a chance to make a comment on anything we've talked about here or out there.*  
A-76: *No comment.*  
Q-77: *Okay. That's all. Thank you. (CHANGE TO TAPE 14)*

Q-1: *This is Day 4. Okay. We'll start out with these. I've got these phrases on these pieces of construction paper and what I'd like for you to do is to try and construct a sentence from them; and you can use all the phrases if you want. You don't have to; you can just use some of them if you want. It's not really as important how many you use as it is that the sentence you construct makes sense to you, or is something that you think is true, or that you would agree with. So, just go ahead and take your time and put something together . . . (short pause) . . . Got it? Okay, why don't you go ahead and read that.*

A-1: Heat energy flows into objects at cold temperatures.

Q-2: *Okay. Could you tell me why you picked that?*

A-2: Well, because the second law of thermodynamics states that heat transfers from the hotter body to the colder body.

Q-3: *Okay. So, you're . . . this is sort of . . . what then . . . your?*

A-3: . . . yeah.

Q-4: *. . . your way of saying that maybe? Okay. Have you seen something or experienced something that shows you that this is true?*

A-4: Yeah. When we did our experiments, the hot from the water, uhh, it went from the hot water into the cold water that was surrounding it.

Q-5: *Umm Hmm. Okay. Now, I'm going to ask you some of these . . . a little about some of these words that you've got here, okay? This term here -- heat energy -- what does that mean?*

A-5: It's the amount of energy that heat produces.

Q-6: *Okay. What about this word here - temperature?*

A-6: That's the measure of how hot or cold something is.

Q-7: *Okay. I've brought this other word over here -- heat? Would you say that this is the same or different from "heat energy"?*

A-7: Different.

Q-8: *Okay. Why would you say they're different?*

A-8: Because "this" is just the . . . the bean of heat and "this" is the energy that heat produces.

Q-9: *Umm Hmm. What do you mean by the "bean" of heat?*

A-9: It's . . . it's just the essence of . . . it's the "object" "heat" and not the energy that it produces.

Q-10: *Okay. What about this idea of heat energy "flowing"? What does that suggest to you? What do you think it means?*

A-10: Heat is . . . is able to move . . .

Q-11: . . . Umm Hmm.

A-11: . . . in and out of things and stuff.

Q-12: *Okay. All right. Well, that's enough for that.*

Q-13: *I'm going to go ahead and ask you something else now. Now, do containers or wraps that help keep hot objects hot also help cold objects cold?*

A-13: Yeah.

Q-14: *Okay, why do you say that?*

A-14: (chuckle) Because it's happened before.

Q-15: (chuckle) *Where at?*

A-15: If you put something cold in a thermos, it stays cold. If you put something hot in the

- same thermos, it stays hot, so.
- Q-16: *Okay. Now, can you think of materials or objects or wraps where that isn't true -- where they work well to keep things hot but they don't work well to keep things cold or vice versa?*
- A-16: No. The best they could work is the same.
- Q-17: *Okay. How is that? How do they work?*
- A-17: Well, like if you take wool, it'd keep something hot and it'd also keep something cold.
- Q-18: *Umm Hmmm.*
- A-18: So it . . .
- Q-19: *Okay. How does it do that? Can you explain how it does that? Or how anything does that?*
- A-19: I can't explain it.
- Q-20: *How can you tell if something does well at doing this or not?*
- A-20: It stays warm longer than something that doesn't work.
- Q-21: *Okay. How would you be able to tell if you had an object that you didn't . . . never worked before?*
- A-21: Could you restate the question?
- Q-22: *Well, if you had an object or a material that you never worked with before, and you didn't really know, how would you be able to tell how well it worked for keeping something hot or keeping something cold?*
- A-22: Doing experiments.
- Q-23: *Okay. Is that how you do things when you run across new materials?*
- A-23: Sometimes.
- Q-24: *What other ways do you figure it out?*
- A-24: I usually don't. I usually just throw something on it and stick it in wherever I'm going stick it. (chuckle)
- Q-25: *Okay. (chuckle)*
- Q-26: ***Let's talk about computers now, okay? Think about the ELabBook Computer Program that you used in class. Do you remember that?***
- A-26: Umm Hmmm.
- Q-27: ***Okay. What I want to do is, I'm going to show you a scale right here . . . and what I'd like for you to do is, I'd like for you to rank ELabBook on this scale in comparison to all the other software programs that you've used before.***
- A-27: . . . (short pause) . . . I would say "this one".
- 
- Q-28: *Could you read that one?*
- A-28: It's okay but I've never really used anything like it before.
- Q-29: *Okay. I see you changed it a little bit. That's okay. You can do that if you want. I mean, sometimes these may not match exactly what you think of it. How would you state it if you were to state it however you wanted to.*
- A-29: I've never used something that had to do with temperature and all that before so it's basically the only one I've ever used.
- Q-30: *Okay. What about in comparison to any other program you've used? Where would it come in?*
- A-30: Well, I would say like middle or three-quarters down.
- Q-31: *Now, can you tell me why you'd put it there?*
- A-31: Because like some of the other programs I've used are a lot more fun (indistinguishable).
- Q-32: *Okay. Go ahead.*
- A-32: Like the software on the Internet Software and stuff like that.
- Q-33: *What makes that software fun that ELabBook wasn't?*
- A-33: Well, you can talk to other people like across the country and stuff. It's not just you

- working at your own little station with a partner or whatever.
- Q-34: *Okay, and why does that make it more fun?*
- A-34: Well, because you're interacting with other people you don't know.
- Q-35: *Okay. Were there any things about ELabBook that you liked?*
- A-35: Yeah. I liked doing the simulations. That was cool.
- Q-36: *Okay. Why did you like that?*
- A-36: Because I think it was fun seeing how stuff worked and stuff.
- Q-37: *Okay. Anything else about it that you liked?*
- A-37: Not really.
- Q-38: *Okay. Were there any other things about it that you wished . . . that you didn't like or you wished were better?*
- A-38: Speed.
- Q-39: *Speed?*
- A-39: It was too slow.
- Q-40: *Were there any particular parts that you thought were too slow?*
- A-40: Uhh, basically just the . . . like the analysis and stuff. It was slow.
- Q-41: *Can you give me an example of something that happened slow?*
- A-41: Like . . . uhh, it took a while to . . . like if you were to place something somewhere, it took a while for it to load it into that . . . into that particular place . . . just . . .
- Q-42: *Okay. Now, think about the opinion you had of ELabBook when you first started using it and then the opinion you had of it later on. What I want to ask you is, did your opinion change over time?*
- A-42: No, not really.
- Q-43: *Okay.*
- A-43: It stayed the same.
- Q-44: *Okay. Do you think it was easy to use?*
- A-44: Yeah.
- Q-45: *How so?*
- A-45: It was basically clicking, dragging, and stuff like that, so.
- Q-46: *Was there any part of it that you thought was difficult?*
- A-46: Uhh Uhh (no).
- Q-47: *Okay. What did you think about those notes that you were asked to fill in?*
- A-47: They were all right but they . . . they took a while though . . . to fill out.
- Q-48: *Umm Hmmm. Is that good or bad?*
- A-48: It's good in some ways and bad in others.
- Q-49: *Yeah?*
- A-49: I can't name those ways.
- Q-50: (chuckle) *Okay. Now, do you think this program was valuable to you in learning science?*
- A-50: Yeah.
- Q-51: *How so?*
- A-51: Well, it taught us about thermodynamic energy and stuff like that, so.
- Q-52: *Can you think of something specific that you learned from this?*
- A-52: Like which wraps work better in keeping stuff warm.
- Q-53: *Anything at all.*
- A-53: (Indistinguishable)
- Q-54: *Which one worked better?*
- A-54: Wool and Styrofoam.
- Q-55: *Now, would you want to teach someone else how to use this program?*
- A-55: Sure.
- Q-56: *Why?*
- A-56: Just to get them acquainted with the system and how it worked and . . . so they could learn the stuff I did.
- Q-57: *Okay. Do you think "you" could teach them?*



A-57: Umm Hmm.

Q-58: *Okay. Well, that's all the questions I have. What I wanted to do is give you an opportunity to make a comment about anything we've talked about here or anything that happened out there.*

A-58: (Inaudible).

Q-59: *Okay. Well, that's it. I want to thank you.*

- Q-1: *This is Day 4. Okay. We're going to start with this. I'm going to get out these phrases on construction paper. (chuckle) You remember this, uhh? And what I'm going to ask you to do is to construct a sentence with these phrases. Now, you can use all these phrases if you want to. That'd be fine. If you don't use them all, that's okay too. I'm not as concerned about how many of these you use, but I'm very interested though in finding out whether the sentence you construct is something that you agree with or that you find to be true or that you think makes sense to you. So, go ahead and take your time if you would do that ... (long pause) ... Got it? Okay. Could you go ahead and read that?*
- A-1: Heat energy flows into the cold energy.
- Q-2: *Okay. Can you tell me why you think that's true?*
- A-2: Uhh, because when something is like ... if you put some hot water somewhere and there's cold water somewhere, the heat from the hot water is gonna go ... the heat flows from the hottest to the coldest.
- Q-3: *Okay. Now, you were thinking of something when you were talking about water. What were you thinking of?*
- A-3: I was thinking of the experiment we did.
- Q-4: *Okay. Can you describe that?*
- A-4: The potato. I was thinking of the law of thermodynamics.
- Q-5: *Okay. So, now, have you seen this happen? This law that you're talking about -- the law of thermodynamics? Have you seen it happen somewhere?*
- A-5: No ... well, yes ... from the sun to (indistinguishable). (chuckle)
- Q-6: *Okay. Okay. Now, I'm going to ask you about a couple of these terms. What does this term here -- heat energy -- mean to you?*
- A-6: Uhh, let me see, like electrical things ... like a socket, a electrical socket where the heat energy and stuff goes through.
- Q-7: *Okay. What about this term here -- cold energy? What does that mean to you?*
- A-7: I don't know ... uhh ... I don't know.
- Q-8: *Okay. I'm going to ask you about this other word over here -- heat. What does that word mean to you?*
- A-8: Hot ... something hot.
- Q-9: *Okay. Do these two words ... are these the same -- heat and heat energy -- or are they different?*
- A-9: Uhh ... they're dif ... I think they're different.
- Q-10: *Okay. Why would you say that?*
- A-10: 'Cuz ... I don't know. Heat is ... heat energy is a kind of heat.
- Q-11: *Umm Hmmm.*
- A-11: I believe there's different kinds of heats and that is just one of them -- heat energy or something else.
- Q-12: *Okay. What about this word over here -- temperature. What does this mean to you?*
- A-12: How hot or cold something is.
- Q-13: *Okay. Okay. That's all for that part.*
- Q-14: *Now, for the second part. What I want to do is, I want to just ask you a question and then maybe do some follow-ups to that. The question I want to ask you is, do containers or wraps that help keep hot objects hot also work well to keep cold objects cold?*
- A-14: Probably not.

- Q-15: *Okay. Why would you say that?*
- A-15: *Because wool . . . like I say, probably wool or cotton or somethin' to keep something . . . it's like really to use to keep something hot and to keep the cold air out, you know?*
- Q-16: *Umm Hmmm.*
- A-16: *It cools but if you have somethin' cold, I don't think it would keep it cold. I think it'd end up getting cold also.*
- Q-17: *Okay. What would be an example of something cold?*
- A-17: *Ice.*
- Q-18: *Okay. So, if you wrapped it in ice?*
- A-18: *Wrap the wool around ice?*
- Q-19: *Umm Hmmm.*
- A-19: *The wool would probably get cold.*
- Q-20: *Okay. I was wondering . . . are there any materials that work well for keeping things hot and for keeping things cold?*
- A-20: *Probably aluminum foil.*
- Q-21: *Okay. Why would you say that?*
- A-21: *Because I've seen somebody put pop in some aluminum foil and they put it in a locker or something for lunch, and when they got it out, it was still cold.*
- Q-22: *Umm Hmmm.*
- A-22: *(Indistinguishable) they put a baked potato in some . . . uhh . . . in some aluminum foil to keep it warm.*
- Q-23: *Okay. Have you seen . . . I mean, have you worked with any of these things . . . have you seen any of this that you're talking about?*
- A-23: *Umm . . . yeah.*
- Q-24: *What have you used to kind of . . . ?*
- A-24: *Usually aluminum foil.*
- Q-25: *Okay. Have you done the "pop thing"?*
- A-25: *Umm Hmmm.*
- Q-26: *Okay. Well, that's all for that.*
- Q-27: *Let's talk about computers now, okay? Think about that ELabBook Program we did? Do you remember that?*
- A-27: *Umm Hmmm.*
- Q-28: *Okay. I'm going to show you a scale and what I'd like for you to do is to rank ELabBook on this scale and compare it to all the other computer programs that you've used before.*
- 
- A-28: *All right.*
- Q-29: *Okay. Can you read that one?*
- A-29: *It was okay but I've never used anything I've really liked.*
- Q-30: *Okay. If you want to make up a different item, that'd be fine. You don't have to use one of these.*
- A-30: *It was great but I wouldn't pick it as the best.*
- Q-31: *Okay.*
- A-31: *Or it's not . . . it wasn't that bad either.*
- Q-32: *Okay. Was there anything about it that you liked?*
- A-32: *Typing.*
- Q-33: *Yeah? Why did you like that?*
- A-33: *I don't know. I just like to type.*
- Q-34: *Are you saying, just to hit the keys or to actually type to say something?*
- A-34: *To type to say something . . . uhh, on the computer.*
- Q-35: *Okay. Was there any other things about it that you liked?*
- A-35: *The demo's and stuff we did.*

- Q-36: *Okay. What did you like about those?*  
A-36: Just guessing and stuff.  
Q-37: *What were you guessing?*  
A-37: Uhh, guessing which wrapping or something would keep what cold.  
Q-38: *Umm Hmmm.*  
A-38: Or how much it would drop . . . how much the temperature would drop, or something.  
Q-39: *Okay. Now, is there anything about ELabBook that you didn't like?*  
A-39: Uhh, having to keep making them notes.  
Q-40: (chuckle) . . . *And what didn't you like about that?*  
A-40: Because I was getting tired of typing and stuff and then we didn't think about . . . I mean, you had to really really think . . .  
Q-41: *Umm Hmmm.*  
A-41: . . . about what it . . . and some of those questions, I didn't really understand.  
Q-42: *Okay. Did you find that . . . when you said earlier that you liked the typing and now you said that . . .*  
A-42: Well, you know . . . you know (chuckle), I mean, not the typing. It was just like having to think about it so hard.  
Q-43: *I see. I get you. Okay. Was there anything else you didn't like about it?*  
A-43: Uhh Uhh (no).  
Q-44: *Okay. Now, think back to when you first started to use ELabBook and your opinion of it at that time and then your opinion of it after you'd used it for a while. Did your opinion change over time or did it stay about the same?*  
A-44: It stayed the same.  
Q-45: *Okay. Now, do you think ELabBook was easy to use?*  
A-45: Yeah.  
Q-46: *Why do you say that?*  
A-46: Because all you had to do was follow the directions . . . read the directions and follow them.  
Q-47: *Okay. Where were the directions at?*  
A-47: Hmmm?  
Q-48: *The directions -- where were they?*  
A-48: In a little box. It told you what to do and stuff.  
Q-49: *Okay. Now, do you think this program was valuable to you in learning science?*  
A-49: Yeah.  
Q-50: *In what way?*  
A-50: Uhh, it helps you to remember things better, like uhh, that principle . . . like the principle notes and stuff?  
Q-51: *Umm Hmmm.*  
A-51: . . . where you try your best to guess them correctly and all that.  
Q-52: *Okay. Was there anything specific that you learned about through the program?*  
A-52: Yeah.  
Q-53: *Can you tell me what "something specific" you learned?*  
A-53: The third law of thermodynamics.  
Q-54: *Umm Hmmm.*  
A-54: Heat flows from the hot . . . warmest object to the coolest object.  
Q-55: *Okay. Now, would you want to teach someone else how to use this program?*  
A-55: Not really. (chuckle)  
Q-56: (chuckle) *Why not?*  
A-56: Because some people can't really understand things the way you want to explain to them. You gotta have patience to explain it to 'em.  
Q-57: *Okay, but do you think you "could" if you had to?*  
A-57: Umm Hmmm.  
Q-58: *Okay. I want to go back and cover one thing. When you said from the start that you*

*said it was okay, what were some things that would have made it better . . . like more . . . more like some of the programs that you like a lot?*

A-58: Have something like a game or something dealing with heat or something.

Q-59: *Okay. Why do you like that?*

A-59: Like you could . . . like you could make . . . you got a . . . like those little cars you hit?

Q-60: *Umm Hmm.*

A-60: It could be like a game where you could make a sentence out of those words before something gets you, or something like that.

Q-61: *(Chuckle) Okay. Why do you like that?*

A-61: I don't know. It's a challenge.

Q-62: *Okay. Anything else that you . . . think of other things that you like, other programs that you liked a lot that this could have used?*

A-62: Umm. No, not really.

Q-63: *Okay. Now, that's all the questions that I have but I want to give you a chance to make a comment about anything we've talked about here or a comment about anything that happened out there.*

A-63: I don't have any.

Q-64: *Okay. That's all. Thank you very much.*

A-64: Okay.

- Q-1: *This is Day 5. Okay, first thing I've got is, I've got these phrases on this construction paper here; and what I'd like for you to do is to take these phrases and try and construct a sentence. Now, you can use all the phrases if you want to. If you didn't use all the phrases, that's okay too. I'm not as interested in seeing how many phrases you can use as I am in seeing that whatever you construct is something that makes sense to you, or something that you would agree with, or something you think is true. So, if you would go ahead and do that. Just take a few minutes or take your time . . . just a minute . . . like I was saying, go ahead and take your time and make your sentence.*
- A-1: . . . (short pause) . . . Objects.
- Q-2: *Okay. So you want to use just "objects"?*
- A-2: Yes. Objects.
- Q-3: *Okay, why don't you go ahead and read that?*
- A-3: Heat energy flows around lower and higher objects at . . . uhh uhh.
- Q-4: *Do you want to take some more time here?*
- A-4: Yeah.
- Q-5: *Okay. That's fine.*
- A-5: Cold. Hot ain't in here?
- Q-6: *You can pretend that that's "hot" if you want.*
- A-6: All right . . . hot objects, that's what I want.
- Q-7: *Okay. Now try reading that again.*
- A-7: Heat energy flows around cold and hot objects.
- Q-8: *Okay. Now, why did you pick that sentence?*
- A-8: Because, you know, you can have like . . . a . . . an egg in a glass of water right here and the heat is on, instead of flowing around it, the same as you got like a cup of ice, the heat still flows around it, no matter if it's cold or warm. It doesn't matter.
- Q-9: *Okay. Now, what does this term here mean to you -- heat energy?*
- A-9: The heat produced from a furnace or something like that.
- Q-10: *Okay. In the little picture you just talked about a minute ago, what would heat energy be?*
- A-10: The furnace.
- Q-11: *Okay. When you were talking . . . when you described . . . you said, heat energy flows around cold and hot objects, you said it's like when you have water and . . . okay, what would be the heat energy in that case?*
- A-11: The temperature.
- Q-12: *Okay. Now, let me ask you this. What is this idea of energy flowing mean to you? Of heat energy flowing?*
- A-12: What's that again?
- Q-13: *This idea of "heat energy flowing", what does that mean to you?*
- A-13: It mean that the heat is just making a big old circle. It just flows around and around until the heat goes off and then it stops.
- Q-14: *This is just for the tape but you're making like a big circular motion with your left . . . your right hand when you do that. Now, I just want to show you another word here -- temperature. What does this word mean to you?*
- A-14: In number wise, or just . . . ?
- Q-15: *Anything. What does it mean to you?*
- A-15: It means, you know, how hot or cold it is outside or degrees, or stuff like that, like 22 degrees Celsius. That would be the temperature or some stuff like that.

- Q-16: *Okay. Now, I'm going to take this and let's make it "heat" again, okay? This word "heat" or "hot", what does this mean to you?*
- A-16: Warm.
- Q-17: *Now, would you say that this is the same as "heat energy" or different?*
- A-17: Different, a little bit.
- Q-18: *In what way?*
- A-18: 'Cause heat energy is like . . . is doing sumpin'. . . it's like "heat energy" is for . . . really for a cause because it's using energy to heat something up.
- Q-19: *Umm Hmmm.*
- A-19: Rather than "heat", you could just be hot in a sweater, that kind.
- Q-20: *Okay. That's all for this part.*
- Q-21: *Now, we'll move on to the next part. What I want to do is ask you a question and then a couple of follow-ups to that. What I'd like to ask you is, do containers or wraps that help keep hot objects hot also keep cold objects cold?*
- A-21: Uhh uhh (no).
- Q-22: *No. Okay. Why would you say that?*
- A-22: Well, like in the project that we did, we had a sock . . . a wool sock. Well, a wool sock may keep something hot but it really . . . a wool sock wouldn't keep nothin' warm 'cause it's insulated to keep somebody warm rather to keep you cold.
- Q-23: *Okay. Now, how is it insulated to do that?*
- A-23: Hard and thick wrapping that stuff has, how thick it's made, how thick they make wool.
- Q-24: *Okay. Now, how exactly does it insulate something?*
- A-24: Why, it would keep it warm on the inside when you put it on . . . as soon as you put it on, it like keep the heat inside from going out and stuff and keeping your foot warm, or whatever you got on that's insulated.
- Q-25: *Okay, now how come it wouldn't work to keep something cold?*
- A-25: 'Cause, well, it depends on what kind of thing you got. Some things are made insulated to keep stuff cold and keep stuff hot.
- Q-26: *Umm Hmmm. Can you give an example of something like that?*
- A-26: Uhh, some of them thermoses made by Thomas and all of them, how they just make . . . make stuff that just keeps cold stuff cold, you know, like your lunch thermos when you used to carry a lunch box, how you could put Kool Aid in it and sometimes, it would still be cold, the way the thermos was made.
- Q-27: *Umm Hmmm.*
- A-27: And stuff like that.
- Q-28: *Okay. Can you think of something that . . . well, can you think of a situation or something that "you've" done . . . I mean, you talked about the thermos where you were able to see something that only kept something hot or only kept something cold . . . you sort of talked about this a little bit . . . ?*
- A-28: All I see is something that keeps something hot like the ones we just did, keeping the water hot?
- Q-29: *Umm Hmmm.*
- A-29: That's what I saw, how to keep hot in by using a whole bunch of different wraps and stuff.
- Q-30: *Umm Hmmm.*
- A-30: But to keep something cold, just put it in the refrigerator.
- Q-31: *Okay (chuckle). All right, that's all for that part.*
- Q-32: *Let's talk about computers now. Think about the ELabBook Computer Program that we did. Do you remember that?*
- A-32: (Inaudible)

- Q-33: *Okay. I'm going to show you a scale and what I'd like for you to do is to rank ELabBook on this scale in comparison to all the other computer programs that you've used before.*
- A-33: What's the rating?
- Q-34: *Just where would ELabBook fit? Which one of these . . . which one of these statements makes . . . would you say about ELabBook in comparison to all the other programs you've used before.*
- A-34: I . . . (short pause) . . . I'll say this one (sounds as though someone is thumping the table with a finger).
- Q-35: *Okay, can you read that?*
- A-35: I picked . . . I picked this as the best but I don't think about other ones.
- Q-36: *Okay. Now, what was it about ELabBook that you picked as the best?*
- A-36: Uhh . . .
- Q-37: *Why did you do that?*
- A-37: Why did I pick ELabBook?
- Q-38: *Umm Hmm.*
- A-38: 'Cause the candy made us do it.
- Q-39: (chuckle) *Is there . . . what were some of the things you liked about it?*
- A-39: Oh, you know, using the computer, having to get up and see what the temperatures was and reading instructions on how you had to answer all them questions about it . . .
- Q-40: *Umm Hmm.*
- A-40: . . . and stuff like that.
- Q-41: *Okay. Why did you like that?*
- A-41: 'Cause I never really did nothing like that with the computer except like maybe do . . . like type a report out but I've never really used the computer like that . . .
- Q-42: *Umm Hmm.*
- A-42: . . . where I had to constantly work and look in books and other kind of material to find the answer.
- Q-43: *Okay. (END OF SIDE A AND START OF SIDE B OF TAPE 13) Okay, so you said it was kind of different . . . a kind of change from what you did before.*
- A-43: Umm Hmm.
- Q-44: *Okay. Is there anything about it that you didn't like?*
- A-44: Uhh Uhh (no). I liked the whole program basically.
- Q-45: *Okay. Think about . . . think about when you first started using ELabBook, and your opinion of it when you first started it, and then your opinion as time went along, later on.*
- A-45: When we first started doing it, I really didn't understand it so I thought it was dumb and I really didn't want to do it, but after a while after I started working into it, it got funer and funer (more fun), you know, because we had to go through the checklist and keep up with what we had to do and answer and stuff like that; so after a while it got fun but when I first started, I thought it was going to be dumb.
- Q-46: *Okay. Why did you think it was going to be dumb again?*
- A-46: 'Cause I ain't . . . I ain't . . . I haven't really done nothing like that before, working with the computer and that kind of material and stuff, so I just thought: "well, since I never did it, it's going to be kind of stupid but I didn't really understand."
- Q-47: *Okay. Now, did you think that ELabBook was easy to use?*
- A-47: After . . . after I listened to the instructions and need . . . and learned what I needed to do, it was real easy, 'cause I . . . once somebody told me what to do, I knew how to do it and I remembered and it was just easy to do. It all came to like . . . flowed in place.
- Q-48: *Okay. Were there any specific things that you thought were real easy? Like what exactly was . . .*



- A-48: Well, when we first started studying temperatures and stuff like that, that was real easy.
- Q-49: *Okay. Now, what did you think about those notes that you had to fill in?*
- A-49: It was . . . it was cool because, you know, we used it in them notes. Sometimes, you had to use your own opinion and what you think everything really does or what it's used for. It means you had to use your mind a little bit and you don't have to just always keep going to the book like for the right answer all the time. The answer that'd be always kind of sly, well then you could use your opinion.
- Q-50: *And you liked that?*
- A-50: Uhh Huh (yes).
- Q-51: *Okay. Do you think this program was valuable to you in learning science?*
- A-51: Yep.
- Q-52: *Okay. In what way?*
- A-52: 'Cause now . . . now, I know a little bit more about computers and stuff; that way, you know, science . . . the way science is today, it's getting more high tech and using computers. It's like that little thing we just did now, if I keep doing it, I'll get better and better at it and science will just be easy.
- Q-53: *Okay. Can you think of anything specific that you learned about heat?*
- A-53: The way it flows. I . . . like the second law of thermodynamics.
- Q-54: *Okay, and what was that?*
- A-54: Heat travels from the warmer body to the cooler body.
- Q-55: *Okay. Would you want to teach someone else how to use this program?*
- A-55: (Inaudible)
- Q-56: *Yeah?*
- A-56: Umm Hmmm.
- Q-57: *Why?*
- A-57: Because if they didn't understand it and they thought it was like hard and thought it'd be dumb because they didn't understand, maybe they'd like it because they'd learn something new just like I did.
- Q-58: *Okay. Do you think "you" could teach them?*
- A-58: Yep 'cause it's . . . once you get the basic stuff down, and you know it . . . and you've already been using a computer before, once you got the instruction and stuff, it would be real easy
- Q-59: *Okay. Now, that's all the questions I have for you but I want to give you an opportunity to make a comment about anything we've talked about here or something that we did out there.*
- A-59: Uhh . . . well, I know that if I ever wanted to keep something warm, I could always use a wool sock, you know. Something . . . actually something thick and heavy to put around it. If I don't have it, I'd go buy me a thermos or something or create my own.
- Q-60: *Okay. Is that all?*
- A-60: Yep.
- Q-61: *All right. Thank you very much.*
- A-61: All right.

## **APPENDIX D**

This Appendix contains some screen images of the teacher and student interface for ELabBook. Stern (2000) has a collection of screenshots that trumps this for detail and clarity, so for a more intense ELabBook experience I suggest looking at her article.

**teacher\_interface**

---

**Experiments**

experiment name:      simulation     realtime     thought

question:  ↑ ↓

rate graph     table

description:  ↑ ↓

2 independent objects     2 objects in contact

dependent variable:

variable name	unit	visible	controlled	fixed at	choices/range (no spaces after commas, only <>,<>)	initial
surface area		√	√	fixed a	small-large	?
volume	ml			fixed a		
initial temperature	°C	√	√		enter data,>0,<201	?
container/wrap		√			"D paper"°C aluminum foil"°B wool"°E saran wrap"°	?
room temperature	°C	√	√		enter data,>0,<40	?
temperature difference	°C				enter data,>0,<201	
time	min					
rate of heat source						
hot object temperature	°C					
liquid						
Situation						

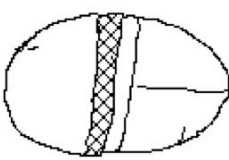
Principle(s):  ↑ ↓

	sequence name	dates	computers	periods	
1	potatoesSeq	now	all	all	<input type="button" value="go to notes"/>
2					<input type="button" value="go to sequence"/>
3					

Worksheet(s):

single-click to see appropriate picture  
double-click to change specification

styrofoam,container/wrap,s	↑
wool,container/wrap,w	
aluminum foil,container/wrap,m	
saran wrap,container/wrap,r	
paper,container/wrap,p	
nothing,container/wrap,n	
?,container/wrap,n	↓



This is the teacher interface for the potato simulation. The simulations have a complete setup from the CLP programmers to use, including drawings of the potato (or object of interest). The teacher can go off script at any time. The field in the bottom center defines the options from which the student can select to run comparisons, and complements the options made available in the middle section.

**teacher\_interface**

---

**Experiments**

experiment name:   simulation  realtime  thought

question:  
 rate graph  table

description:

2 independent objects  2 objects in contact

dependent variable:

variable name	unit	visible	controlled	fixed at	choices/range (no spaces after commas, only <>,</>)	initial
surface area						
volume		√			small-large	
initial temperature	°C				enter data	?
container/wrap						
room temperature	°C	√	√		enter data	
temperature difference						
time						
rate of heat source						
hot object temperature						
liquid						
Situation						

Principle(s):

	sequence name	dates	computers	periods	
1	prj_design_realtime	now	all	all	<input type="button" value="go to notes"/>
2					<input type="button" value="go to sequence"/>
3					

Worksheet(s):

*single-click to see appropriate picture*  
*double-click to change specification*

The teacher interface can be used to set up an experiment or simulation. This is the setup for the temperature difference experiment, which unlike the simulations is not “prefabricated.” The teacher would be responsible for all of the setup of the interface for this experiment.

teacher\_interface

---

## Principles

Name:

1) Enter Correct Principle(s) here (1 principle per line):

Heat energy flows faster through a good conductor than through a poor conductor.

Heat energy flows slower through a poor conductor than through a good conductor.

These are the words that will show up:

as  
Cold energy  
flows at the same rate  
flows faster  
flows slower  
Heat energy  
Temperature  
than  
through a good conductor  
through a poor conductor

2) Use "Group" in Font menu to create groups of words in above principle(s)

3) Enter distractors here:

flows at the same rate

as

Temperature

Cold energy

4) Click here:

**Make List**

---

### Prototypes associated with this Principle:

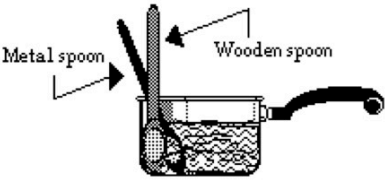
metal & wooden spoon

sam and the poles

**edit prototypes**

**show prototypes**

You stir a pot of boiling noodles with two spoons, one metal, one wooden. Which spoon do you think would get hotter faster?

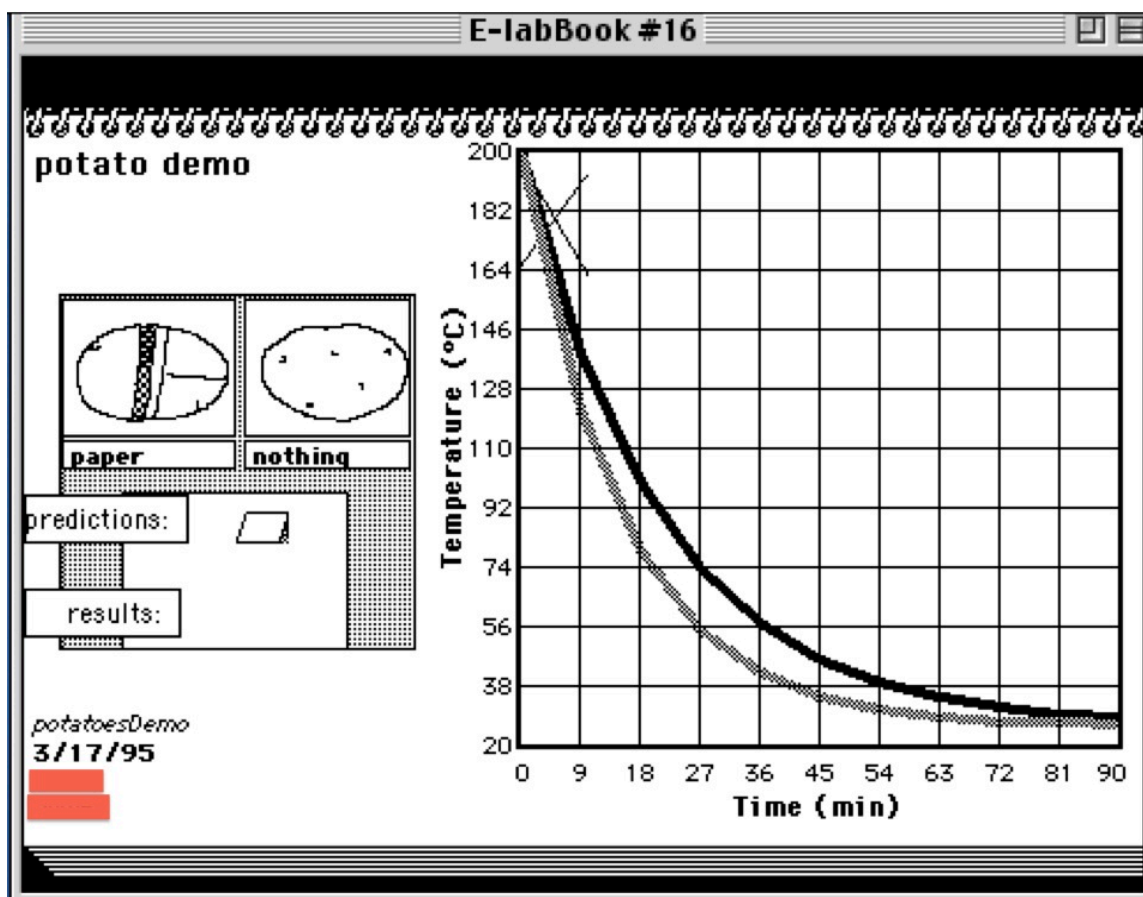


The metal spoon will get hotter faster.

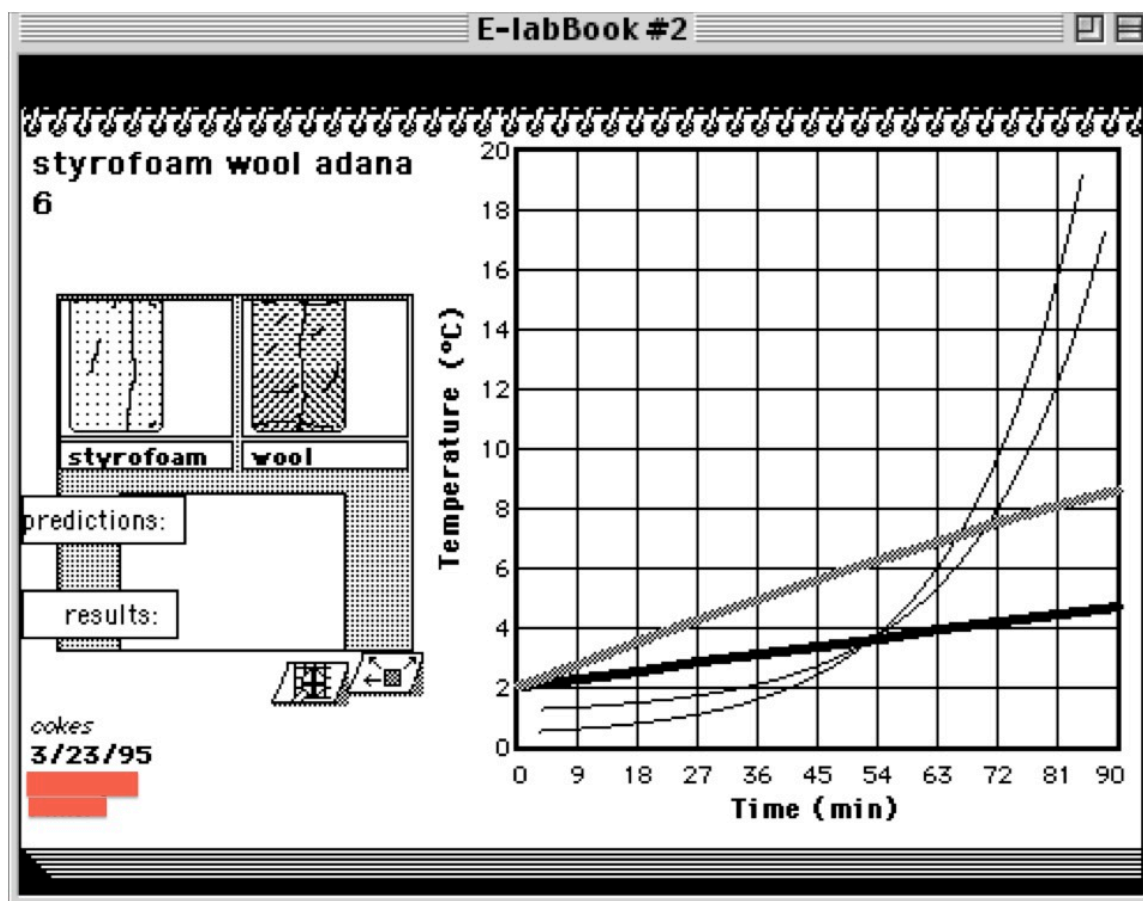
This is the part of the interface where the teacher can do some scaffolding to check for understanding during the experiment or simulation. The top half is where the teacher can create a word scramble, either using the predetermined word choices from the CLP or making up his or her own. The bottom half is where the teacher can select from a list of analogous situations, to check for transfer of understanding from the simulation to one of those situations.



On this screen, the teacher can scaffold the process for the experiment or simulation by determining required and optional aspects and the sequence that must be performed by the students. Required tasks must be done in order; optional tasks can be done at any time or not at all. “Not Allowed” greys out a button so that the student is unable to perform a specific task. “Notes” specifies that words must be entered into a field in order for the task to be complete.



This is part of the student interface for the potato demo simulation. The button that says “predictions” is where the students enter a prediction. The one that says “results” is where they write the analysis of what happened. Setup of the axes includes establishing the range of each axis, making sure that the initial temperature and the length of time for the simulation or experiment are accommodated. The smaller lines near the top are where the students attempt to graph what they think will happen, and the thicker lines are the actual data. The small rectangle is one of the required activities that was determined by the teacher; when the student clicks on it, they go to a different screen. All of the student data is stored on the card file, so either the student or the teacher can review it after the fact at any time.



This is the student interface for the coke simulation. For this simulation, the students were able to choose which insulating material to wrap up the cokes. The two rectangular buttons correspond to the graph analysis and heat flow activities required by the teacher. Note that the students can also give their experiment or simulation a unique name. One can see that the students anticipated higher heat transfer later in the warming process, rather than earlier. As a teacher, this is one of the things I would make sure to review with the students so they would understand why the fastest temperature rise is nearer the beginning.



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