Supports for K-12 Students' Engagement when Learning Online and Remotely

by

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Dedication

For my dad, Bradley J. Ferguson.

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Abstract

The spread of COVID-19 in the spring of 2020 necessitated a global shift to learning remotely which upended traditional pedagogy and curriculum for teachers at every level of education and created new fields of inquiry in learning science. Online and distance education has existed for many years in parallel with the advancing technologies which support it (e.g., videoconferencing), yet to date, research on effective teaching practice in this field is primarily focused at the undergraduate level. K-12 teacher's widespread experimentation with online content and pedagogies throughout the COVID-19 pandemic affords a unique opportunity to examine online and distance teaching strategies which retain elementary, middle, and high school students' interest and enjoyment in learning when learning online and remotely to a more generalizable extent than previously possible. This dissertation encompasses two studies which each examine instructional and pedagogical strategies K-12 teachers used to teach their students online and remotely at two time points during the COVID-19 pandemic, then links these to students' academic and affective outcomes to answer a fundamental question: what worked?

This dissertation utilizes data from the School Connectedness Project, a longitudinal study of K-12 students' learning experiences and educational outcomes between 2017 to 2021 (PI: Dr. Allison Ryan, co-PIs: Dr. Nicole Brass, Sharlyn Ferguson, Jessica Kilday). Study 1 incorporates data from 206 high school students who I surveyed two months after their school had closed per COVID-19 (two months in to their remote learning). Study 2 incorporates data I collected from 1,426 elementary school students regarding their online and remote learning experiences throughout the following 2020-2021 school year, i.e. the first year of the pandemic.

Study 1 examines the array of emergency remote teaching (ERT) strategies implemented in the initial wake of school closures in Spring 2020. The goal of Study 1 was to identify patterns among the online and remote learning opportunities high schoolers reported participating in during this time, and ultimately identify those associated with students' higher levels of engagement in learning and positive affect post-transition (after shifting from learning in person to remotely). Study 1 further clarifies the importance of differences in student's home environments, individual characteristics and daily routines, perceptions towards technology and learning remotely, on student's engagement and positive affect post-transition. Study 2 provides a multi-level investigation of student webcam use in virtual class sessions respective to student academic outcomes. The goal of Study 2 was to clarify student and classroom characteristics predictive of specifically younger students' (elementary school students) (non)use of their webcam in virtual classes, as well as identify whether individual frequency or classroom-level norms of webcam use are tied to students' academic outcomes (level of engagement in learning and end-of-year achievement).

The findings of this dissertation are targeted to provide evidence-based recommendations and guidance to elementary, middle, and high school educators' emergency remote teaching efforts as well as decisions when creating an online course for their younger student populations. These findings also have further implications for future K-12 online and distance learning policies.

Chapter 1 – Introduction

To contain the COVID-19 virus, 195 countries participated in nationwide school closures in Spring 2020, affecting approximately 91% of students worldwide (UNESCO, 2020). School closures are a common tool used to restrict the spread of viruses in communities and have been successfully utilized during previous public health emergencies such as during the influenza and Polio pandemics (Litvinova et al., 2019; Meyers & Thomasson, 2017). Extant evidence finds school closures can have adverse effects on students' academic trajectories and mental health (e.g., Golberstein et al., 2020; Litvinova et al., 2019). Any loss in instructional time is associated with changes in students' academic performance (e.g., Belot & Webbink, 2012), yet *prolonged* school absence is linked to learning loss, which increases student's later risk of dropping out of school and ultimately predictive of their poorer educational attainment (Dupéré et al., 2015; Meyers & Thomasson, 2017; Ichino & Winter-Ebmer, 2004). In tandem with school closures, state and local governments also began to enforce social distancing measures in Spring 2020. In response, extracurricular activities, sports, and other school social gatherings such as graduations and dances were cancelled by school officials for Spring and summer 2020, and for many, into the following fall and winter (Lessard & Schacter, 2020). During this time, children and adolescents around the world experienced remarkable and prolonged upheaval to both their academic and social development, compared to any generation before them.

Historically stressful events – like the COVID-19 pandemic – have repercussions for the development of youth who experience them. Such events cause disruption to youth's daily routines, social networks (e.g. family, teachers, peers) and to their environments (i.e. school, home) which, along with disruptions to larger systems such as within government, and school districts, can bring about wide-ranging and long-term consequences for youth (e.g., Trejo et al., 2021; Liston et al., 2009). Evidence from past historically traumatic events used to forecast learning loss which is likely among youth due to the COVID-19 pandemic predict it will almost certainly have far-reaching consequences for the current and future academic functioning of youth if not mitigated (Igbal et al., 2020; Kuhfeld et al., 2020).

To prevent widespread learning loss, many countries – including the United States – adopted online and distance learning modalities and content delivery to ensure students could continue learning (Drane et al., 2020; Issa, 2020; Johnson, 2020). As learning moved online, educators generally turned to hosting synchronous class sessions via videoconferencing platforms (Marten & Borup, 2022). Global educational systems such as UNESCO specifically recommended K-12 educators prioritize hosting classes virtually as their students learned from home throughout the COVID-19 pandemic, as it was widely considered to be more so engaging for children and adolescents (Bernacki et al., 2020) as well as would provide them with opportunities for continued normal daily interactions with their peers and teachers (UNESCO, 2020).

The technology for hosting classes via videoconferencing platforms and online teaching and learning research on its use has existed for many years (e.g., Hampel & Hauck, 2004;

Bernard et al., 2004), yet research on use of these formats in general K-12 education settings is exceedingly rare. Before the COVID-19 pandemic, online teaching and learning research was almost exclusively focused at the undergraduate level (Bernacki et al., 2020). When school-age populations were studied, the goal was to improve educational access to children and adolescents traditionally excluded from in-person education (e.g., students with disabilities, hospitalized students, Burgstahler, 2002). Thus, previous findings were not generalizable to K-12 learning. Likewise, temporarily shifting instruction to a medium that could reach students at home (e.g., online, or via paper packets and/or workbooks) until a return to the classroom was needed at the start of the pandemic; K-12 educators did not need to create an online course, as there was little time to plan and circumstances were considered temporary. Thus, online and distance learning research was largely not appropriate to address either the situation nor to address the learning needs of K-12 student populations during this time.

Little was known regarding how best to shift younger students from learning in person to online, or even more importantly, online and pedagogical content and strategies which could best keep them engaged in learning both initially as well as when online and remote learning became prolonged. As most primary and secondary schools switched to online teaching and learning at some point after schools closed in response to the pandemic (Natanson & Strauss, 2020), K-12 educators subsequent widespread experimentation with online learning modalities and instructional deliveries to teach their students throughout the pandemic now provides a fruitful avenue for identifying and better understanding online and distance teaching practices and learning supports which promote and sustain K-12 students' engagement in online learning to a more generalizable extent than previously possible.

School-provided online and remote learning was an attempt to mitigate the negative consequences of prolonged school closures for children and adolescents' learning and the societal impact of a generation of students at greater risk of later life poorer educational and economic outcomes. However, for these efforts to have succeeded, the opportunities provided must have effectively engaged youth.

1.1 Engagement

Engagement is fundamental to learning; students must actively involve themselves in learning – via their interaction with learning materials and activities, or by communicating with their peers and teachers – to facilitate the learning process (Dewey, 1902; Vygotsky, 1978; Piaget, 1971). While researchers in educational psychology and educational technology generally agree engagement is the energy or effort that students put forth into learning (Martin & Borup, 2022; Fredericks, 2008), there is less consensus as to what this effort entails. Most consistently, engagement is thought to contain at least an *emotional* and a *behavioral* aspect, each uniquely predictive of academic achievement separately yet also predictive of the other (Martin & Borup, 2022). *Emotional* engagement encompasses the level of affective attachment a student holds for what they are learning (e.g., interest or enjoyment), while *behavioral* engagement is the behavior – and more typically manifestations of physical effort – that a student puts forth into learning (e.g., raising one's hand to answer a question, asking for help, paying attention, Fredericks, 2008).

Engagement has been of interest to education research for decades as it is reliably predictive of student's future academic outcomes yet is also subject to change as supports are added to the learning environment (Ryan et al., 2019). Students' higher levels of engagement are associated with their improved learning (Wigfield et al., 2008), higher standardized test scores

and grades (Skinner et al., 1990), and higher educational aspirations and attainment (Cornell et al., 2016). However, there is lacking consensus between the fields of educational psychology and educational technology as to how to define and measure engagement and the focal environment where supports for it are studied. Educational psychology research has traditionally assessed engagement in person learning settings and typically has not considered student's use of learning technologies to be an integral part of their learning experience. Nor has it considered online learning environments to be learning spaces which contain factors that promote (and diminish) student engagement in learning (Martin & Borup, 2022). Conversely, educational technology research has not yet achieved a consistent conceptualization and measurement of engagement comparatively (Bond, 2020; Martin & Borup, 2022), yet has identified unique supports in online learning environments and specific utilizations of technology which provide even greater opportunities for students' engagement in learning than what is capable of a traditional in-person classroom (Keren-Kolb, 2013; Mishra & Koehler, 2006). Thus, considering both fields is not only desirable but necessary to better understand the nuances in student learning which occurred online and remotely during the COVID-19 pandemic.

Engagement is particularly useful to study in this instance – i.e., what was effective COVID-19 emergency remote learning – as it is important for students' academic and emotional adjustment regardless of where learning occurs. As students moved from learning in person to online, what remained of primary concern was whether or not they were engaged. Declines in student engagement were noticeable at the start of the pandemic and persisted to be of public concern as students' remote learning became prolonged (Miller et al., 2021). It is now widely acknowledged that school-provided remote learning during the pandemic did not adequately engage youth (e.g., Dorn, 2020; U.S. Department of Education, 2022). Yet increased acceptance

of online teaching and learning formats within K-12 education due to their widespread implementation during the COVID-19 pandemic is likely to continue boosting demand for and integration of online courses and remote learning options in K-12 education in the future (Allen et al., 2016; Barbour & Reeves, 2009; Dhawan, 2020; Neuwirth et al., 2020; Schwartz et al., 2020; Toppin & Toppin, 2015). Likewise, in recent years, school-age children and teachers have increasingly encountered threats to their physical safety at school which infringe on their ability to meet in-person (e.g., school shootings, bomb threats, staffing shortages, increasing climate disasters such as wildfires, polar vortex, and snow days; Juvonen, 2001; McAplin & Slate, 2021; Lambert et al., 2020; Hodges et al., 2020; Aspergren, 2020). Taken together, there is a need for education research to provide evidence-based guidance and recommendations specifically to K-12 teachers as to how to design and implement online and remote learning activities which are engaging for their younger students, as well as how to best shift their instruction online quickly and effectively in case of emergency.

1.2 Overview of Dissertation Studies

The purpose of this dissertation is to examine and summarize a sample of K-12 students' online and remote learning experiences in the immediate aftermath of school closures and throughout the 2020-2021 school year, linking these to their academic and emotional outcomes, to ultimately provide evidence-based recommendations and guidance for elementary, middle, and high school instructors' future online and emergency remote teaching efforts. Study 1 and Study 2 of this dissertation together ask the following two research questions: 1.) What was K-12 students' online and remote learning like at the start of the pandemic and during prolonged remote learning (the 2020-2021 school year), and 2.) What online and remote instructional and

pedagogical strategies were associated with K-12 students' higher levels of engagement in learning and emotional well-being throughout this time?

I specifically sought to study and identify better supports for two challenges to K-12 educators' planning and effectiveness in engaging children and adolescents during COVID-19 emergency remote learning, 1. providing an engaging sequence of learning for adolescent students after shifting instruction from in-person to emergency remote teaching (ERT), and 2. educators' decisions regarding K-12 students' webcam use in virtual classes and when learning online. Each study will focus on tying variation in children and adolescents' self-reported online and remote learning experiences and behaviors to variation in their academic and emotional adjustment (i.e., engagement, positive affect, and/or achievement) to help inform K-12 educators future efforts.

1.2.1 Study 1

Surveys administered in the first months of the COVID-19 pandemic identify adolescents typically report greater difficulty learning remotely compared to elementary school students (Polikoff, 2020; Yan et al., 2020). Adolescents are an already at-risk population for disengagement in learning as well as experiencing psychological distress during times of instability (Eccles et al., 2003). Adolescence is also the developmental stage when students typically have a greater need for peer socialization in their learning (Patrick et al., 2007; Ryan et al., 2019), which was likely increasingly difficult to satisfy during social distancing and while learning remotely. To this end, Study 1 utilized an adolescent student sample (grades 9-12) in order to examine online and distance teaching and learning strategies which more effectively engaged this student population after an abrupt shift from learning in-person to remotely.

Study 1 objectives were three-fold. First, Study 1 utilized a data mining technique in order to find commonalities among the emergency remote teaching (ERT) experiences that adolescents reported 2 months after they had transitioned to learning remotely at the onset of the COVID-19 pandemic (i.e., 2 months after school closures). Second, these commonalities were utilized as predictors in two autoregressive models where students' self-reported engagement and positive affect were the respective outcomes in order to identify ERT experiences that were associated with students' greater engagement and emotional adjustment post-transition. Finally, stepwise inclusion of individual, home, and ERT predictors into these models and analysis of changes in explained variance were used to shed light on the relative importance of ERT experiences on adolescents' post-transition engagement and affect respective to other factors in their lives during this time (i.e., their home support and resources, as well as individual perceptions and daily routines). In summary, Study 1 sought to identify not only what ERT strategies worked best among an adolescent student sample but also whether the ERT they experienced mattered more or less so for their engagement and adjustment after abruptly shifting to learning remotely relative to other factors in their lives.

1.2.2 Study 2

Study 2 explores students' and classrooms' (non)use of webcams while attending virtual class sessions during COVID-19 emergency remote learning. Research on videoconferencing as a mode of instructional delivery is a generally underdeveloped area of research (Lawson et al., 2010), yet the efficacy of webcam-based courses in K-12 general education settings in relation to younger students' academic outcomes is essentially non-existent.. Likewise, establishing parameters for K-12 students' webcam use in virtual classes is a topic of interest to the public, as parents and educators alike debated whether to require student webcam use in virtual classes

throughout COVID-19 emergency remote learning (Will, 2020; Reed, 2020). Thus, Study 2 sought to 1.) understand characteristics of elementary school students' and classrooms' associated with students' greater webcam (non)use in virtual class sessions, 2.) clarify whether students' webcam use is associated with how engaged they are in learning (i.e., behavioral and emotional engagement), 3.) disentangle the relationship between student and classrooms' webcam use and level of engagement by assessing how each predict student's individual academic achievement (i.e., students' end-of-year state achievement test scores).

Study 2 incorporates a sample of elementary school students to better investigate webcam use within a multi-level context, as recent evidence suggests students' webcam use is both an individual- as well as group-level construct.

1.3 Conclusion

This dissertation will address several gaps in our understanding of the online and distance learning experiences of K-12 students throughout the COVID-19 pandemic. I specifically focus on identifying ERT strategies utilized by K-12 educators to shift their students online at the onset of emergency remote learning and the COVID-19 crisis, as well as students' webcam (non)use during virtual classes during the school year that followed (2020-2021), to differentiate and define K-12 online and remote instructional and pedagogical strategies which best supported children and adolescent engagement in learning. These findings can contribute to emerging good practice in how K-12 teachers plan instructional approaches and activities within a sequence of planned or emergency online teaching. Addressing gaps in our understanding of effective K-12 online and remote learning that occurred throughout the pandemic is greatly needed, as the demand for these options in K-12 education continues to grow.

Chapter 2 – What Worked? Emergency Remote Teaching (ERT) Approaches Predictive of Adolescents' Greater Engagement in Learning and Positive Affect Post-Transition

2.1 Abstract

Emergency remote teaching (ERT) has become the default instructional format when teachers and students cannot meet in person, yet few studies have identified strengths and weaknesses of different ERT approaches respective to K-12 student outcomes. This study sought to identify commonalities among adolescents' (Grades 9-12) ERT experiences at the start of the COVID-19 pandemic and identify those associated with higher levels of engagement and positive affect (after controlling for a variety of individual- and home-level factors). Participants were 206 U.S. high school students residing in the rural Midwest (59% female, 91% White, M_{grade}=10.4). Two months after transitioning from learning in-person to learning remotely (May 2020), students answered survey questions regarding the online and distance learning opportunities they had participated in, as well as on their home lives, daily routines, technological capability, confidence, and attitudes towards learning remotely. Principal components analyses identified 5 patterns among the ERT experiences students reported: *Teacher transitional support, Zoom-heavy, Heavy workload, Chaotic,* and *Heavy social load*. Autoregressive analyses identified *Teacher transitional support* ERT predicted both higher levels of engagement and positive affect post-transition. *Heavy workload* and *Heavy social load* ERT also predicted higher levels of engagement post-transition, yet neither were predictive of adolescents' more positive affect post-transition. *Chaotic* and *Zoom-heavy* ERT each exhibited

null associations with post-transition level of engagement and affect. Stepwise analyses of variance identified students' ERT experiences explained as much of the variance in adolescents' level of engagement post-transition as home environmental factors, yet ERT experiences did not explain variance in adolescents' post-transition positive affect. The results of this study shed light on ERT practices which support adolescents' continued engagement in learning after shifting to learning online, as well as provide insight regarding the relative importance of ERT, home, and individual-level factors for students' academic and emotional adjustment at the start of the COVID-19 pandemic.

2.2 Introduction

As schools closed in the spring of 2020 in response to the spread of the COVID-19 virus, the initial priority for educators was access; to ensure all students were capable of learning remotely. Schools in the U.S. are mandated to provide equal access to instruction to all K-12 students, as such, hundreds of thousands of Chromebooks were bought by U.S. school districts during this time to achieve this goal (Issa, 2020; Johnson, 2020). The next priority for K-12 educators was to develop and implement a remote learning plan, yet how do we teach children and adolescents remotely? Little empirical evidence existed that could help guide K-12 teachers' transitioning of their in-person course online or into a format that could reach students at home. Before the COVID-19 pandemic, identifying effective practices in online and distance education was more often the focus of inquiry at the undergraduate level (Bernacki et al., 2020). When school-age populations were the focus, the aim was to improve educational access to those traditionally excluded from in-person education (e.g., students with disabilities, hospitalized students, Burgstahler, 2002). Thus, previous findings were not generalizable to K-12 learning. Further, educators did not need to construct an online course at the start of the COVID-19

pandemic. Initially, the objective was to temporarily shift in-person instruction and learning activities online (or provide them remotely via paper packets and workbooks) until a return to classrooms was possible (Bernacki et al., 2020; Hodges et al., 2020). As such, this is emergency remote teaching, or ERT (Hodges et al., 2020).

There is increasing demand for online and distance learning options for K-12 students. Recent studies suggest widespread adoption of these learning formats during the COVID-19 pandemic has generally made them more acceptable within K-12 learning contexts (e.g., Schwartz et al., 2020; Barbour, 2020; Dhawan, 2020). For example, "remote learning days" – shifting instruction to online or remote delivery on a temporary basis – are now commonly utilized by elementary, middle, and high school principals and educators when threats to students' and teachers' physical safety at school make in person teaching and learning impossible (e.g., bomb threats, water main breaks, staffing shortages; dangerous weather events such as snow days, Aspergren, 2020). In essence, ERT has become the fallback instructional option during times of crisis at every level of education (Hodges et al., 2020) and will almost certainly remain a standard skill set of K-12 teachers. Identifying effective ERT practices for K-12 student populations has become a new educational research field.

The COVID-19 pandemic necessitated a radical societal shift to working, learning, and socializing remotely for a much longer period than initially expected. For schooling, the initial ERT efforts in the spring of 2020 were critical for a smooth transition into an adequate remote pedagogy for the 2020-21 school year. It's important now that we go back to this time, to these initial ERT efforts, and identify strengths and weaknesses of different ERT approaches to better prepare for future needs to implement ERT.

2.2.1 ERT

Researchers have begun to assess ERT efforts during the COVID-19 pandemic. To date, most of this evidence is qualitative; collected via interviews with undergraduate students and professors at public universities (Almahasees et al., 2021; Elmer et al., 2020; Fabriz et al., 2021; Nilsberth et al., 2021) or via interviews with K-12 students' parents and teachers (but not with the students themselves)(e.g., Whalen, 2021; Trust & Whalen, 2021; Domina et al., 2021). This is likely because opportunities for recruitment and assessment of K-12 students became increasingly limited during the pandemic. However, as a consequence, we currently know far more regarding ERT practices which work well for undergraduate and K-12 instructors than ERT practices which are effective to use with K-12 students. Specifically, no study to date has yet identified associations between K-12 students' ERT experiences and their educational outcomes.

At the undergraduate level, some tentative quantitative findings exist. In a study which surveyed undergraduate students at a large German university, Fabriz and colleagues (2021) found undergraduates who spent more time in synchronous class sessions over videoconference during emergency remote learning reported having more numerous opportunities for peer interaction (e.g., feedback on work) and likewise, reported higher levels of perceived support for their competence and relatedness needs than students who experienced mostly asynchronous ERT. At the end of the semester, students who had had more synchronous time reported greater satisfaction with the semester overall. In another study of undergraduates' learning experiences at the start of COVID by Zhou and colleagues (2021), they found ERT characterized by increased social presence, a greater variety of tasks, and students experiencing flow while learning (Csikszentmihalyi, 1990) was associated with undergraduate students' greater acceptance of learning online during COVID. They additionally found students' attitudes

towards their ability to learn online were crucial for their ability to self-regulate their learning during this time. These findings represent a start towards identifying effective ERT strategies.

However, ERT which works well for undergraduate students is unlikely to generalize to K-12 student populations. K-12 students have much different needs for autonomy and relatedness in their learning compared to undergraduate students (Musgrove & Musgrove, 2004; Ryan & Powelson, 1991; Barbour & Reeves, 2009). For example, elementary school students have less developed self-regulatory abilities than undergraduate students; they more often struggle to maintain their attention in synchronous class sessions, more often lack the ability to self-direct their learning when learning online, as well as participate in academic discussions online with others in a way that is meaningful for their learning (Keating, 1990; Casey & Caudle, 2013; Barbour, 2013; Huffaker & Calvert, 2003; Wang et al., 2013). Recent studies also identify ERT strategies utilized during the COVID-19 pandemic were more and less preferred by K-12 students depending on their stage of development. Yan and colleagues (2021) surveyed a wide range of K-12 students (grades 1-12) regarding their ERT experiences one month after they had started learning remotely; they found elementary school students (grades 1-6) more frequently sought help from their teachers and relied on them during emergency remote learning, conversely, high school students (grades 10-12) more frequently sought help from their peers or to try to solve comprehension problems on their own (Yan et al., 2021). It is well-established that online teaching practices customized to the pedagogical needs and preferences of learners are more successful at retaining students interest in learning (Musgrove & Musgrove, 2004; Leech et al., 2022). Thus, attention to K-12 students' varying developmental needs is needed when identifying and formulating effective ERT for this population.

The objective of the current study was to identify ERT strategies which better supported adolescents' engagement and positive affect (i.e., happiness, enjoyment of and hopefulness about life) after transitioning from in-person to learning remotely. Studies during the COVID-19 pandemic consistently identify middle and high school students report greater difficulty learning online and remotely during this time compared to elementary school students (Polikoff, 2020; Yan et al., 2021). Adolescents are an already at-risk group for disengagement in their learning yet are especially vulnerable to disengagement and psychological distress during times of instability compared to other age groups (e.g., undergoing a middle school transition, Eccles et al., 1993; Casey & Caudle, 2013). Further, there is evidence that ERT during the COVID-19 pandemic typically lacked opportunities for students to interact and collaborate with peers (Bączek et al., 202; Elmer et al., 2020; Fabriz et al., 2021), yet adolescence is a stage of development when peer interactions and relationships become increasingly important for adolescents' engagement in learning and perceived well-being (Berndt, 1979; Keating, 1990; LaFontana & Cillessen, 2010; Ryan, 2000; Patrick et al., 2007). The goal of this study was to inform recommendations and guidance for middle and high school instructors by considering specifically adolescents' ERT experiences and outcomes.

This study asks the following research questions:

RQ1. What were common patterns among adolescents' ERT experiences at the onset of the COVID-19 crisis?

RQ2. Which ERT approaches better supported adolescents' engagement and positive affect after transitioning from in-person to remote learning?

RQ3. What was the relative importance of ERT, home-, and individual-level factors in adolescent's engagement and positive affect at the onset of the pandemic?

2.2.2 Quantity, quality, and variety of online learning activities

Although there is limited information as to how best to transition an in-person course online, prior work consistently finds changing the medium for instruction does not change instructional quality or students' learning outcomes (Cavanaugh et al., 2004; Bernard et al., 2004; U.S. Department of Education, 2010). In other words, prior empirical consensus is that it is not likely important to consider whether students learned more if they attended a lecture in person or watched the same lecture via videoconference; if students watch the same lecture either way, learning outcomes should be the same if students were not distracted (Crompton, 2017; Bernacki et al., 2020). However, recent studies have investigated and found evidence that whether students learned fully online, hybrid (some in-person and some remote instruction), or fully in-person during the COVID-19 pandemic – with the same or similar pedagogy and curriculum – produced different learning outcomes among youth (e.g., Bettinger et al., 2020). Thus, it may be that the *time* students spent learning in different mediums may tie to student's academic and emotional adjustment.

Distance and online learning research often measure the quantity, quality, and variety of online and offline learning activities students are assigned, as each are consistently tied to students' better learning outcomes. The number of hours students spend participating in online learning activities predicts academic performance (Xie et al., 2012; Nieuwoudt, 2020). Online course designs that assign a larger number as well as variety of online learning tasks are positively associated with students' higher level of engagement and enjoyment in learning (Nguyen, 2021). The intensity of participation required in order to complete online course tasks (e.g., assignments that merely ask students to view online learning content vs. assignments that require they participate in deep discussion) is also tied to students' level of engagement

(Hrastinski, 2008). However, students' perceptions of having a heavy workload – having too many online learning tasks and/or that they are spending too much time on online coursework – is consistently associated with (specifically undergraduate) students' lower academic motivation in online learning environments (Hartnett, 2015; Aristovnik et al., 2020).

Extant evidence also identifies online learning activities can augment student engagement in ways that are much more difficult to achieve through solely in-person instruction (Mishra & Koehler, 2006; Keren-Kolb, 2013). When undergraduate students participate in both synchronous and asynchronous online learning activities as well as attend in-person classes, they tend to report higher levels of engagement and ultimately have better course outcomes than students who attended in-person classes only (Northey et al., 2015). This research has spurred new frameworks as to what "good" teaching truly entails. The TPACK framework (Mishra & Koehler, 2006) and Triple E framework (Keren-Kolb, 2011) both conceptualize technological knowledge as a new realm of knowledge which teachers must have alongside that of having adequate pedagogical and content knowledge. Therefore, current frameworks emphasize that not only should teachers know how to use technology, but that they should also know which online learning activities are most engaging for their students, as well as how best to incorporate technology such that it extends and enhances student learning (Keren-Kolb, 2011). Diversity among teachers' implementation of a variety of formal and informal online content and pedagogies throughout the COVID-19 pandemic (e.g. synchronous and asynchronous learning activities, online modules and forums) then provides a unique opportunity to examine the online and remote learning activities students participated in and for different lengths of time, and identify those which more effectively kept students of different ages engaged in learning and well-adjusted after shifting from in-person to remote.

2.2.3 Time spent in synchronous & asynchronous activities

Previous studies often classify and compare online and distance courses and learning activities as either synchronous or asynchronous (Nguyen, 2021; Hrastinski, 2008; Fabriz et al., 2021; Skylar, 2009). Synchronous and asynchronous activities differ in terms of the time and place of teaching and learning: Asynchronous learning is temporally and geographically independent, self-directed and self-paced, and requires less presence from an instructor, synchronous learning is temporally dependent (requires simultaneous presence of learners and instructor) yet allows for their geographical independence. Synchronous learning (such as whole class sessions via videoconference) is often linked to students' greater engagement and motivation (both among undergraduate and high school students: Hrastinski, 2008; Fabriz et al., 2021) as well as positive affect (Nguyen, 2021). Many suggest this is because synchronous learning better mimics the real-time interaction which happens in a classroom (Bernacki et al., 2020). However, synchronous learning activities also require students have adequate technological infrastructure – with the bandwidth, equipment, and technological support needed to participate and/or at the same capacity as other students. Further, synchronous learning requires a higher cognitive load which may inconvenience younger learners (Martin & Borup, 2022).

Empirical consensus among studies conducted during emergency remote learning has identified a mix of synchronous and asynchronous activities as ideal for learners (e.g., Nguyen, 2021; Hrastinski, 2008; Fabriz et al., 2021). However, there does not appear to be a "golden ratio" of synchronous to asynchronous activities; studies find the ideal combination of synchronous to asynchronous in online learning environments varies depending on the subject matter and learning goals of the class (Fabriz et al., 2021) as well as the developmental stage and

age of the learners involved (Musgrove & Musgrove, 2004; Yan et al., 2021; Shaw & Pieter, 2000). While there is conflicting evidence regarding whether students in general prefer synchronous or asynchronous work while emergency remote learning (Gillis & Krull, 2020; Nguyen, 2021), previous online learning studies consistently find older learners do well with mostly asynchronous work (likely due to the greater flexibility and autonomy it provides, which are conducive to their developmental needs)(Musgrove & Musgrove, 2004; Shaw & Pieter, 2000), while recently, younger learners report preferring learning in person rather than online and also report a clear preference for mostly synchronous work while emergency remote learning (Yan et al., 2020; Nguyen, 2021).

2.2.4 Teacher support

There is ample evidence high quality teacher-student relationships provide an important foundation for adolescents' academic motivation, engagement in learning, and well-being at school (Fredricks, 2011; Quin, 2016; Roorda et al., 2011, 2017; Wang & Eccles, 2012; Wentzel et al., 2010). Positive interactions with teachers increase students' valuing of learning (Wang & Eccles, 2012) and improve their feelings of acceptance and connectedness to others at school (Cortina et al., 2017; Zimmer-Gembeck et al., 2006; Allen et al., 2018). Ryan and colleagues (2019) describe a variety of ways that teachers build emotionally supportive relationships with their adolescent students in their classrooms, such as by communicating positive expectations for student success, showing appreciation for positive behavior, and asking questions to get to know them. As many students transition from familiar elementary schools to a new middle school during adolescence, teacher-student relationship quality becomes especially important (Hughes & Cao, 2018). High quality teacher-student relationships are tied to adolescents' perceived fit at their new school, which in turn, predicts their later academic engagement and achievement

within this new learning context (Zimmer-Gembeck et al., 2006). Thus it might be expected that during a transitional period in adolescents' lives – such as transitioning from learning in-person to learning at home – the extent to which teachers are able to create and/or preserve warm relationships and interactions with their students would foster similar associations during emergency remote learning.

Positive and caring interactions between students and teachers are also crucial for student learning in online environments (Robinson et al., 2017). Online and distance learning can cause students to feel isolated while learning, which can be detrimental to student's academic motivation, success, and psychological well-being (Palloff & Pratt, 2007). Online teachers use a variety of means to communicate care to their students, such as positive affirmations and feedback (Berry, 2019), one-on-one phone calls and virtual office hours (Miller, 2021), and by providing opportunities to share information about themselves with the class and with peers virtually (Mastel-Smith et al., 2015; Händel et al., 2022).

Teacher-student interactions also provide important structure for student learning, in in-person contexts but especially in online learning contexts (Moore, 1989). In traditional classroom settings, teachers provide frequent feedback and guidance throughout the learning process, such as by walking around the room and answering students questions as they work. In online learning environments, teachers' clear communication of rules and expectations as well as provisioning of timely feedback become particularly important for student motivation and engagement; this is because gaining necessary feedback is more difficult for students when they are learning online as lack of physical proximity both inconveniences and delays student help-seeking (Hartnett, 2015; Barbour, 2013). Lack of instructor presence in online learning contexts is tied to adolescents' poorer attention, weaker recall of information, and poorer satisfaction when

learning online (Wang & Antonenko, 2017). During emergency remote learning, adolescents often reported seeking out answers to their questions on their own, either by searching them via search engine or by rewatching a previously recorded lecture, and less often asked their teacher or peers for help by comparison (Yan et al., 2021). Thus, teachers who were still able to provide their students with frequent feedback as well as clear expectations and rules for their newly instituted remote work were likely much more successful in retaining their students' interest in learning post-transition.

2.2.5 Opportunities for peer interaction

Learning is both a cognitive and a social process, whether it occurs online or in-person (Vygotsky, 1978). Numerous small- and large-scale studies find teachers' provisioning of opportunities and supports for students' interaction with peers on academic tasks uniquely contributes to student engagement and achievement when learning online (Bickle & Rucker, 2010; Cheung et al., 2008; Moos & Azevado, 2008; Hartnett et al., 2011; Nguyen, 2021). In traditional classroom settings, aspects of the classroom social environment – such as students having friendly relationships and interactions with peers – are consistently linked to adolescents' academic and emotional adjustment within these contexts (King, 2015; Patrick & Ryan, 2005; Schmidt et al. 2019). This is likely because during adolescence, peer friendships and status become of increased priority for youth relative to earlier stages of development (LaFontana & Cillessen, 2010). When teachers provide adolescents opportunities to collaborate with peers, it is related to adolescents' higher behavioral engagement as well as more frequent offering of academic help and advice to classmates (Patrick et al., 2007).

The findings of recent COVID-19 studies suggest peer collaboration opportunities were of particular importance for adolescents' continued engagement in learning during the COVID-

19 pandemic. Chiu and colleagues (2021), utilizing a sample of 8th and 9th graders, found adolescents' perceived relatedness with peers and with their teachers were the most important predictors of their engagement while emergency remote learning (Chiu, 2021). As such, this study hypothesizes ERT with more collaborative formats (with discussion, small group work, and peer-to-peer feedback opportunities) likely better supported peer social interactions and thus, adolescent students' engagement in learning as well as their well-being during this time.

2.2.6 Home environment and daily activities

When students learn from home, their learning more greatly relies on the people they live with, and the habits and norms that they and others have created within this environment. Households vary in their ability to provide youth with financial and social supports and resources that better allow them to prepare and adapt to new stressors in their lives (Drane et al., 2020; Domina et al., 2021). Home environments that were able to provide better support for students' remote learning, such as a quiet study space, reliable WiFi/internet connectivity, and functioning up-to-date devices, likely attenuated students' risk for academic and emotional maladjustment after shifting to remote (Drane et al., 2020; Lederer et al., 2021; Rudenstine et al., 2020). The pandemic also introduced additional stressors into families: increased rates of parental unemployment (Wang et al., 2021), loss of income (McKune et al., 2021), death of loved ones, and increased familial conflict (Wang et al., 2022a) – each linked to adolescents' increased anxiety, depression, and psychological maladjustment during the pandemic.

Adolescents' personal routines were also disrupted by the pandemic and by the abrupt shift to remote, which in turn, likely affected their mental health and their desire to engage in learning. Unmet physiological and psychological needs distract youth from fulfilling higher-level needs such as achieving academically (Maslow, 1943) as well as diminish their ability to self-

regulate their emotions (Li et al., 2020). Adolescents' daily routines at home, such as the amount of sleep they had each night (Wang et al., 2022a), how often they exercised and spent time outdoors (Wang et al., 2022b), and interactions with friends and family (Song et al., 2004; Ellis et al., 2020) have each been linked to their psychological and academic adjustment at the start of the pandemic. Much less explored by this prior work is adolescents' daily responsibilities and distractions due to siblings. Studies find adolescents frequently reported experiencing distractions from siblings and/or others at home during emergency remote learning. In their study of K-12 students during COVID-19, Yan and colleagues (2021) found students in grades 1-12 reported disengagement from learning due to frequent distractions from others in their home nearly as often as experiencing disengagement due to poor Internet connectivity.

Students' technological capability and self-efficacy are also important to consider relative to their engagement and affect when learning online (Fabriz et al., 2021). Adolescents' technological skills vary; it is likely not all had the level of proficiency needed to successfully engage in online learning tasks before shifting to online at the start of the COVID-19 pandemic (Drane et al., 2020; Margaryan et al., 2011). Indeed, most K-12 students did not have prior experience learning online prior to the COVID-19 pandemic (Molnar et al., 2019; Barbour & Reeves, 2009). One recent study found K-12 students expressed some level of confusion with how to utilize the online learning platforms their teachers assigned during emergency remote learning (Yan et al., 2021). Extant evidence consistently links undergraduate students' technological skill and self-confidence utilizing technologies to their more positive affect and motivation when learning online (Cheung et al., 2008; Moos & Azevedo, 2008; Hartnett et al., 2011; Kauffman, 2015; Muilenburg & Berge, 2005). Inexperienced online learners more frequently have poorer academic performance and motivation in online learning contexts

compared to students with some prior experience learning online (Molnar et al., 2019; Muilenburg & Berge, 2005). Thus, students' technological capability and self-efficacy will be important factors to consider in virtually any study which aims to connect efficacious ERT strategies to students' learning outcomes – which is quite often not the case among the recent literature on this topic.

In sum, students' home environment, their daily routines, and technological capability and confidence, will likely influence students' engagement and affect in ways that are outside the influence of the ERT their teachers provided during this time. Thus, it is important that these factors are accounted for and controlled among the study variables.

2.2.7 Summary

From this prior literature emerges a list of factors which likely play a role in effective Emergency Remote Teaching (ERT) strategies for adolescent students: 1.) The quality, quantity, and variety of synchronous and asynchronous learning activities provided, 2.) provisioning of opportunities for social interaction with teachers and peers, 3.) teachers' providing structure for students' learning (i.e., timely communication of high-quality feedback and guidance regarding online and remote learning tasks) as well as communication of care for their students. Further, it's important that these are differentiated from individual-level factors, such as differences between student's home environments and individual skills, perceptions, and behaviors, especially with regard to their technological resources and literacy.

2.3 Methodology

2.3.1 Participants

The sample consisted of 206 adolescents from a high school located in the rural Midwest (59% female, 91% White, 24.5% enrolled qualified for free or reduced-price lunch). Students in the sample had been given school-issued Chromebooks approximately two years before the COVID-19 pandemic, which they carried with them from class to class and used in their learning during this time. Therefore, the sample provided a unique opportunity to investigate effective ERT practices among adolescent students at the onset of the COVID-19 pandemic that was not confounded with the effect of familiarizing with the device.

2.3.2 Procedure

Surveys were developed in a consulting capacity in an ongoing research-practice partnership with school-level stakeholders to assess their students' learning experiences, academic motivation, and general well-being. After communications about their school and their interest in a survey, an initial draft of the survey was sent to the superintendent and school principal, whose feedback and suggestions were considered to improve it. Students were either prompted by their principal and/or by one of their teachers to complete the survey during virtual class time or asked to complete it on their own along with their other assigned remote work. Hyperlinks to the survey were provided to students either via their student email, through their learning management system, or dropped into the Chat box during a synchronous class session.

Students completed the survey online via Qualtrics two months after they had transitioned to learning remotely (in May 2020). Students were informed on the welcome screen of the survey that their participation in the survey was completely voluntary, that there were no right or wrong answers, and that their responses would be deidentified and kept confidential from their teachers, principals, parents, and peers. Survey development and data collection were solicited by the school district and a shared data agreement regulated and the use of these data

for research. These analyses are classified as non-regulated human research according to the Code of Federal Regulations (45 CFR 46.102 (l)) and the University's institutional review board provisions.

57% of students enrolled participated in the survey; this was likely because students were given greater autonomy to complete the survey as well as were residing at home at the time of survey administration. This participation rate is comparable and/or exceeds the participation rate of other online student surveys administered to adolescents at the onset of the COVID-19 pandemic (Elmer et al., 2020; Chiu, 2021; Yan et al., 2021 – 7%)

2.3.3 Measures

Dependents

Students were asked to rate 10 items which measured their engagement and positive affect relative to two time points. First, they were asked to rate these items according to first how they had felt *before* transitioning to remote learning (i.e., how they felt while learning in-person 2 months prior). Then they were asked to rate the same statements again in a separate column, but now thinking about how they felt *currently*, while learning remotely.

Engagement was assessed via 7 statements from an adapted version of the School Engagement Scale (Fredricks et al., 2005). Students responded to the prompt, "*Please tell us how often you have felt the following BEFORE and AFTER the shift to remote learning*". Example statements from this measure included *"*interest in schoolwork", "enjoyment in learning new things", "try hard on assignments", "staying focused on my work", and "doing my work even when I do not feel like it". Students responded on a 5-point Likert scale to each statement (1 = *never*, 5 = *all the time*); their responses were aggregated twice, first set of responses were aggregated to measure students' engagement while learning in-person (Cronbach's $\alpha = .853$), the

second set of responses were aggregated to measure student's engagement while learning remotely (α = .839).

Positive affect was assessed via 3 statements from Positive Affect subscale of the Center for Epidemiologic Studies Depression Scale (CES-D; Garrison et al., 1991), which has been validated for use with adolescents (Blodgett et al., 2021). Students were asked "*How often have you felt the following emotions BEFORE and AFTER the shift to remote learning?*". Statements included, "happy", "enjoyed life", "hopeful about the future". Students responded using a 4-point Likert scale (1 = *rarely or none of the time*, 4 = *most of the time*). Students' first set of responses were aggregated to measure positive affect while learning in-person (α = .823); the second set of responses were aggregated to students' positive affect while learning remotely (α = .814).

Home-level covariates

Given that remote learning is taking place at home, various questions asked about students' home environment and support.

Home support. Five statements asked students to report the level of social support they had at home for their remote learning. Statements asked how frequently they had someone at home who helped them with their remote work, helped them organize their work and checked to make sure it was completed, and helped them with technology if they needed it. Students responded to each statement on a 5-point Likert scale (1 = *not at all*, 5 = *almost always*). Responses to each statement were aggregated to create the final measure which exhibited good internal reliability, α = .80.

Frequency of home distractions from siblings/others was assessed by a single item. "How often do you have problems with distractions from siblings and/or others at home while remote learning?" (1 = *almost never,* 5 = *almost all the time)*.

Frequency of WiFi/internet connectivity problems was assessed via the item, "How often do you have problems with your Wi-Fi or internet connectivity when doing schoolwork at home?" (1 = *never,* 4 = *daily or almost daily)*.

To assess ***frequency of device problems*** while remote learning at home, students were asked, "How often do you have problems with device(s) or technology when doing schoolwork at home?". Students responded on a 4-point scale (1 = *never,* 4 = *daily or almost daily)*.

Perceived difficulty learning remotely was measured via one item. Students responded to the statement, "Staying at home to do my work has been…" on a 3-point scale (1 = *easier than I expected*, 2 = *about what I expected*, 3 = *harder than I expected*).

Competence using webtools was measured via students' ratings of how easy it was for them to use the webtools their teachers assigned and required them to use while learning remotely. Examples of webtools students typically used were provided in the prompt ("for example, Google Classroom, Schoology, ClassDojo, etc."). Students responded to this item were on a 5-point scale (1 = *not easy at all*, 5 = *very easy*).

Individual-level covariates

Students were asked to select their ***gender*** from the following four answer options: 1.) girl (she/her); 2.) boy (he/his); 3.) non-binary (they/them, ze/zie); 4.) prefer not to answer. No students self-identified as non-binary. Four students who preferred not to answer had their response regarding their gender coded as missing. Comparisons by gender are then between girls and boys only in the analyses.

Daily activities. Students were asked to report the number of hours they typically spent engaged in the following activities during a typical school day while learning remotely: 1.) sleeping; 2.) exercising and/or going outside; 3.) doing something by yourself that you enjoy

(such as watching TV, reading a book, or playing games on your phone); 4.) socializing with friends online/virtually; and 5.) taking care of responsibilities at home (such as chores or caring for siblings). Students typed the number of hours they typically spent on each activity. Responses to each item were not aggregated but kept separate as individual covariates; means for daily hours spent sleeping, spent exercising and/or going outside, spent doing something by yourself for fun, socializing with friends online/virtually, and spent taking care of responsibilities at home are listed in Table 2.1.

Emergency Remote Teaching (ERT) experiences

Survey questions that assessed students' ERT experiences were organized into two categories: *pedagogical* experiences (i.e., the specific teaching methods and the underlying pedagogy of the ERT they experienced) and *instructional* experiences (i.e., quantity, quality, and variety of synchronous and asynchronous activities they participated in and for different lengths of time during a typical day of emergency remote learning). Survey questions that measured ERT experiences were identified as possible leverage points based on prior review of relevant literature (see Introduction). **Appendix A** provides full descriptions of these variables.

Due to the large amount of data collected via the survey on students' ERT experiences, principal components analysis (PCA) was utilized to maximize data interpretability. PCA is a data-mining technique that reduces the dimensionality of data by transforming a larger set of variables into a smaller set of uncorrelated linear combinations, thus maximizing ability to interpret the data while minimizing information lost from the larger set. In this study, only variables which assessed ERT experiences specifically were included in the PCA model. Thus, each linear combination (i.e., component) identified via the PCA model represents a common pattern to emerge among students' remote learning experiences.

As there were no prior ERT component structures or frameworks to reference upon the writing of this study, ERT measures were included and excluded in different combinations in a series of PCA models to determine those that worked best together to produce clear components of ERT. The final PCA model was selected by consensus among the research team; it indicated a five-component solution as best fitting the data and explained the most variance of any previous model (79% variance explained) as well as achieved a Kaiser-Meyer-Olkin value of 0.6 (Field, 2000). The corresponding scree plot demonstrated a clear break between the fifth and sixth factors (the eigenvalue for the fifth factor was 1.06). There were no variables included in the PCA model which did not load onto a component (loadings < .30) (see Table 2.1 for correlation matrix).

RQ1. What were common patterns among adolescents' ERT experiences at the onset of the COVID-19 crisis?

Each of the five components identified by the final PCA model is described below; each was transformed into a principal component score before inclusion in all subsequent regression analyses:

1. ***Teacher transitional support*** **ERT** explained 23.8% variance and was characterized by teachers' frequent communication of concern for students' well-being, frequent provision of clear rules and expectations for their work and remote work that students found interesting. Within this pattern, students also reported participation in a greater variety of online learning activities as well as more frequent opportunities for peer collaboration.
2. ***Zoom-heavy*** **ERT** explained 17.9% variance. In this pattern, students spent many hours during a typical day of remote learning in synchronous class sessions and wanted to

spend less time each day in this activity. Students also reported spending few or no hours completing asynchronous work yet wanted to spend more time doing this.

3. ***Heavy workload* ERT** explained 15.8% of the variance. In this pattern, students spent many hours attending synchronous class sessions as well as completing asynchronous work during a typical day of remote learning for them, and also reported wanting to spend less hours doing these activities. Students also participated in a wide variety of offline learning activities on top of this.
4. ***Chaotic* ERT** explained 11.2% of the variance in students ERT experience. Students reported participation in a large variety of tasks they were given both online and offline to complete each day. They also reported their teachers' infrequently provided feedback and/or clear rules and expectations for the remote work they assigned.
5. ***Heavy social load ERT*** explained 10.6% variance. *Heavy social load* ERT was characterized by students reporting of frequent opportunities to collaborate with peers throughout their typical day of remote learning (more than other students reported having during his time), yet this was coupled with the perception that their teachers less frequently demonstrated care for student well-being.

2.3.4 Handling of missing data

The percentage of missing values across study variables varied between 0 and 23%. In total, 58 out of 206 records (28%) were incomplete. Missing data analysis examined whether values were missing completely at random (MCAR). Little's MCAR test (Little, 1988) was not significant, χ^2 (283.69, DF = 249), p = .065, which suggests values were MCAR. To account for variable-level missingness among the sample, multiple imputation was utilized to create 5 multiply imputed datasets. Incomplete variables were imputed under fully conditional

specification, using the default settings of the SPSS Premium 28 package. The parameters of substantive interest were estimated in each imputed dataset separately and combined using Rubin's rules. For comparison, analyses were also performed on the subset of complete cases. Similar results were obtained when analyses were restricted to complete cases only; therefore, only results from the pooled sample are reported.

2.3.5 Analysis plan

Descriptive analyses were conducted to identify the average perceptions and daily routines of the adolescents in the sample to better inform and contribute to historical knowledge of adolescents' lives and adjustment at the onset of the COVID-19 pandemic (see Table 2.1 and 2.2). Zero-order correlations were performed to identify significant associations between all study variables before planning their respective regression models (see Table 2.2). Sensitivity checks examined whether students' engagement, positive affect, and opportunities for peer interaction differed by gender or grade-level. To test the main hypotheses, ERT component scores, home environment, and individual-level covariates were entered in 3 successive steps in two separate autoregression models. Students' engagement post-transition was the outcome of the first model; positive affect post-transition was the outcome of the second model. Step 1 of each model entered all individual-level covariates as well as entered the respective controls for prior levels of engagement or positive affect depending on the model's outcome. Step 2 entered (simultaneously) all four home covariates. Step 3 entered (simultaneously) all five ERT component scores as predictors. At each step, significant change in F was assessed to identify the relative contributions of individual-level, home environment, and ERT factors to explaining the variance in adolescents' engagement and positive affect post-transition (the two dependents). All values of tolerance were above .2 and variance inflation factors (VIF) did not exceed 1.6,

indicating multicollinearity was not a concern in either model. Results of the two regression models are presented in Table 2.3 and 2.4.

2.4 Results

2.4.1 Descriptives

Means and standard deviations for all study variables are presented in Table 2.1 and 2.2. On a typical day of remote learning for them, students spent (in order of magnitude) approximately 7 hours sleeping, 4 hours doing something alone that they enjoyed (e.g., playing a game on their phone or reading a book), 4 hours completing asynchronous schoolwork, 3 hours socializing with friends online, 2 hours exercising or going outside, 2 hours taking care of responsibilities at home (e.g. chores, taking care of siblings), and 1 hour attending synchronous class sessions. On average, students said they would ideally like to spend 15 minutes less each day in synchronous class sessions, and 43 minutes less time each day on asynchronous work.

Independent samples t tests compared students' pre- and post-transition levels of engagement, positive affect, and opportunities for interaction with peers (for description of the opportunities for peer interaction measure, see **Appendix A**). Tests revealed students reported a significant decline in their engagement since having transitioned to learning remotely ($M_{in\text{-}person}$ = 3.82, M_{remote}=2.99, MS=2.20, p=.043, η^2=.25) as well as significant decline in their positive affect ($M_{in\text{-}person}$ = 3.20, M_{remote} =2.74, MS=2.09, p<.001, η^2=.26). Students also reported having significantly fewer opportunities for academic peer interaction while learning remotely than they had previously while learning in-person ($M_{in\text{-}person}$ = 3.84, M_{remote} = 2.37, MS = 2.76, p=.017, η^2=.13).

Correlations between all study variables are presented in Table 2.2. All five component scores were orthogonal to one another due to their extraction method. Although each component

is orthogonal to one another, each still may exhibit significant associations with other measures included in the study that were not included in the PCA. Only two correlations among the study variables exceeded weak to moderate associations. Opportunities for academic peer interaction (in-person) was strongly correlated with the ERT component scores of *heavy social load* ERT (r=.67, p<.001) and *teacher transitional support* ERT (r=.54, p<.001), indicating opportunities for peer interaction likely did not significantly decline for students who experienced *heavy social load* and *teacher transitional support* ERT.

2.4.2 Group comparisons

Univariate tests for gender revealed girls tended to report significantly higher levels of engagement while learning remotely than boys, M_{girls} = 3.06, M_{boys} = 2.88, t (724) = 3.04, p=.002. Younger students (those in grades 9 and 10) reported higher levels of engagement while learning remotely than older students (grades 11 and 12), $M_{9\text{-}10}$ = 3.04, $M_{11\text{-}12r}$ = 2.92, t(742) = -2.21, p=.027, as well as having had more opportunities to interact with peers both while previously learning in-person, $M_{9\text{-}10}$ = 3.94, $M_{11\text{-}12r}$ = 3.68, t(766) = -4.43, p<.001, as well as while learning remotely, $M_{9\text{-}10}$ = 2.62, $M_{11\text{-}12r}$ = 1.98, t(766) = -8.41, p<.001. Older students reported a significantly steeper decline in their positive affect after transitioning to learning remotely, $M_{9\text{-}10}$ = -.39, $M_{11\text{-}12}$ = -.53, t(760) = -2.48, p=.013, as well as in their opportunities for peer interaction after transitioning to learning remotely, $M_{9\text{-}10}$ = -1.31, $M_{11\text{-}12}$ = -1.70, t(766) = -4.53, p<.00, than younger students reported. Boys reported a steeper decline in their engagement after transitioning to learning remotely compared to girls, M_{girls} = -.78, M_{boys} = -.94, t (718) = 2.23, p=.026. There were no other significant group differences identified with respect to students' gender or grade-level among self-reported engagement, positive affect, and peer interaction opportunities.

2.4.3 Regression results

RQ2. Which ERT approaches better supported adolescents' engagement and positive affect after transitioning from in-person to remote learning?

Results indicated *Teacher transitional support*, *Heavy social load*, and *Heavy workload* ERT were each associated with adolescents' higher levels of engagement post-transition (see Table 2.3 for regression coefficients, p-values, VIF and tolerance statistics). *Zoom-heavy* and *Chaotic* ERT were each not predictive of engagement post-transition. *Teacher transitional support* ERT was also associated with adolescents' more positive affect post-transition (see Table 2.4). Neither *Zoom-heavy*, *Heavy workload*, *Heavy social load*, nor *Chaotic* ERT experiences were predictive of adolescents' positive affect post-transition.

RQ3. What was the relative importance of ERT, home-, and individual-level factors in adolescent's level of engagement and positive affect at the onset of the pandemic?

Individual-level factors explained 32% of the variance in adolescents' engagement post-transition; home environment and ERT experiences each separately explained a significant proportion of the variance in this outcome as well (both 13%) (see Table 2.3). Among the individual-level covariates, higher *perceived difficulty learning remotely* was associated with lower engagement post-transition. Higher *competence using webtools* and *engagement pre-transition* predicted higher levels of engagement post-transition. No other individual-level covariates exhibited significant associations with adolescents' engagement post-transition. Among the home-level covariates, greater *frequency of home distractions from siblings and/or others* was associated with adolescents' lower levels of engagement post-transition, while greater *home support* was associated with higher levels of engagement post-transition. Neither *frequency*

of WiFi or internet connectivity problems or *frequency of device problems* were predictive of adolescents' engagement post-transition.

In the stepwise regression model where positive affect post-transition acted as the dependent, individual- and home-level factors each explained a significant proportion of the variance in adolescents' positive affect post-transition (43% and 6%, respectively). However, ERT experiences did not significantly contribute to explaining variance in students' positive affect post-transition (see Table 2.4). Among the individual-level factors, greater *positive affect pre-transition* was associated with greater positive affect post-transition. Greater *perceived difficulty learning remotely* was associated with lower levels of positive affect post-transition. Further, greater *daily hours spent exercising or going outside* was associated with adolescents' more positive affect post-transition. Among the home factors, greater *frequency of WiFi/internet connectivity problems* predicted adolescents' lower levels of positive affect during this time. However, greater *home support* was marginally predictive of students' more positive affect post-transition.

2.5 Discussion

The findings of this study provide initial evidence that differences in adolescents' emergency remote teaching (ERT) experiences at the beginning of the COVID-19 pandemic related to differences in their academic and emotional functioning during this time as well. Adolescents' ERT experiences uniquely predicted their level of engagement in learning and positive affect two months after they transitioned to learning remotely, over and above other home environment and individual-level factors occurring in their lives during this time. Specifically, adolescents in the study sample reported higher levels of engagement in their learning and reported greater happiness, enjoyment of, and hopefulness about life if they had

experienced *Teacher transitional support* ERT, a pattern of ERT experiences characterized by teachers' frequent communication of concern for students' well-being, communication of clear rules and expectations for student work, frequent provisioning of interesting online/remote work, greater variety of online learning activities, as well as frequent opportunities for academic collaboration with peers.

That ERT characterized by high levels of teacher support predicted adolescents' greater engagement in learning and emotional well-being at the start of the pandemic underlines the importance of caring and communicative teachers during periods of instability in students' lives (Eccles et al., 1993). An abundance of research has demonstrated adolescents' positive relationships and interactions with teachers are associated with their greater engagement in learning (Wang & Eccles, 2012; Quin, 2016; Roorda et al., 2011), specifically, teacher-student relationships support adolescents' sense of belonging in new learning environments, which is associated with later increases in their engagement and achievement (Eccles et al., 1993; Zimmer-Gembeck et al., 2006). The findings of this study complement yet extend this prior work. Altogether, the consistent significance of *teacher transitional support* ERT experiences in this study implies that upon adoption of an online (distance) learning plan, instructors should prioritize maintaining supportive communication and interactions with their students. Specifically, this study identified the following supportive emergency remote teaching practices as linked to adolescents' greater engagement and more positive affect after a sudden shift to learning remotely from home: (1) more frequent expressions of concern and accommodations for students' well-being; (2) clear rules, expectations, and consistent feedback regarding their remote work; (3) assigning remote work which students find interesting; (4) assigning a variety of online tasks to complete, and (5) providing frequent opportunities for academic peer interaction.

Teacher transitional support and *Heavy social load* ERT experiences were each predictive of adolescents' higher level of engagement post-transition; both were characterized by teachers' more frequent provisioning of opportunities for peer interaction. During adolescence, peer interaction greatly motivates learning (Engels et al., 2017; Patrick et al., 2007) yet recent studies find that at the onset of the COVID-19 pandemic, ERT often lacked opportunities for collaborative peer experiences (Bączek et al., 2021; Fabriz et al., 2021; Elmer et al., 2020). Indeed, in this study, adolescents reported a significant decline in their opportunities to collaborate with peers since they had shifted to remote, with older students (grades 11-12) reporting significantly less opportunities overall and a steeper decline in these opportunities since transitioning than younger students (grades 9-10). Recent COVID-19 studies also find adolescents reported a greater inclination to ask peers for help and greater preference for peer interaction while emergency remote learning than younger students reported (Yan et al., 2021). Thus, alongside the findings of other studies of K-12 emergency remote learning – the findings of this study call for greater consideration of adolescents' developmental need for peer interaction in their learning in the design of K-12 online courses, online learning platforms and activities in the future – as it may be a fruitful avenue by which to promote this population's engagement in online learning.

Adolescents in this study also reported higher levels of engagement post-transition if they experienced *heavy workload* ERT, or if they reported spending a greater number of hours each day on synchronous and asynchronous schoolwork compared to other students. It is well-known that greater time spent with learning materials (regardless of the mode of delivery) is predictive of increased academic success (Soffer & Cohen, 2019). Thus it is unremarkable to find students who spent more time on academic tasks were more engaged in learning than other students

reported being. Indeed, results indicated students who reported higher levels of engagement before the transition also reported higher levels of engagement post-transition. Yet it is interesting to compare this finding to previous findings among the online learning literature regarding undergraduate students' perceptions of having a heavy workload. Previous qualitative and quantitative studies of online learning typically find students who report a heavier workload in online learning contexts tend to also report being less academically motivated (Harnett, 2015; Aristovnik et al., 2020). Specific to ERT during the COVID-19 pandemic, a case study of Finnish high school students conducted by Niemi and Kousa (2020) found students who reported a heavier workload after shifting from learning in person to remotely also reported greater fatigue and poorer motivation.

Why is heavy workload in this study linked to higher levels of engagement, while previous studies of undergraduates' experiences learning online consistently link heavy workload to lower levels of engagement? This is likely because these previous studies typically do not measure how much *time* students dedicate to various online and offline and/or synchronous and asynchronous learning activities compared to other students to define a heavier workload, rather, students' *perceptions* of their current workload compared to a previous time point are assessed. Thus, associations between a heavier workload and poorer motivation and engagement in these studies likely reflect more of a burnout effect, while associations between a heavier workload and increased motivation and engagement in this study reflect between-student comparisons of actual time spent completing academic tasks. This study then avoided confounding "heavy workload" with perceived increases which do not actually correspond to any more time or effort spent on academic work. For example, studies find inexperienced online learners more often report a heavier workload when learning online compared to learning in person due to the time

and effort they additionally need to adapt to the tools and methods of online learning compared to more experienced online learners (Lowes & Lin, 2015; Yates et al., 2020; Molnar et al., 2019; Muilenburg & Berge, 2005). This study identified ERT with a heavier workload – with students spending more hours participating in synchronous and asynchronous learning activities – as predictive of adolescents' higher level of engagement post-transition, after controlling for students' perceived technological competence and perceived difficulty learning remotely.

Heavy workload ERT could also reflect an optimal combination of learning mediums and time spent on these mediums for this age group. *Heavy workload* ERT was characterized by students spending about equal time on synchronous and asynchronous learning activities, as well as participating in a greater variety of offline learning activities, such as reading a book or completing assignments on paper. Empirical consensus suggests a mix of synchronous to asynchronous tasks is optimal for students of all ages while learning online (Nguyen, 2021; Hrastinski, 2008; Fabriz et al., 2021). Likewise, one recent study of a province-wide survey of Chinese adolescents emergency remote learning experiences identified high school students (grades 10-12) reported greater preference for working offline (e.g., with paper materials) while learning remotely more so than younger students (grades 1-3) reported (Yan et al., 2021). That *Heavy workload* ERT predicted adolescents' higher levels of engagement post-transition, yet *Zoom-heavy* ERT did not, further suggests *Heavy Workload* represents a more optimal ratio of synchronous and asynchronous time which was more so engaging for adolescent students, rather than spending more time on these tasks in general.

It is important to note that this study did not find *Heavy Workload* ERT was predictive of students' more positive affect post-transition. Thus, assigning high school students, or adolescents in general, a greater amount of academic online or remote work to complete after

transitioning from in-person to learning online during a crisis may coincide with these students spending more hours on schoolwork and subsequently their reporting of being harder working than others during this time, but this may not necessarily translate to their fewer internalizing symptoms or less psychological distress.

Another interesting finding of this study is that there was not evidence of "bad" ERT necessarily. No ERT experiences predicted adolescents' lower level of engagement or lower positive affect post-transition. Both *Zoom-heavy* and *Chaotic* ERT were each not predictive of students' level of engagement nor positive affect 2 months after transitioning to remote. While null associations for *Chaotic* ERT are more intuitive – that teachers' assigning a variety of academic tasks with minimal guidance or feedback neither benefits nor causes great detriment to adolescents' learning or well-being – the finding that *Zoom-heavy* ERT was not predictive of adolescents' lower level of engagement or positive affect was surprising. There is widespread acknowledgement and evidence which supports the existence of "Zoom-fatigue" (Blanchard, 2021). Further, as students tend to ascribe greater importance to peer judgements and self-presentations during adolescence (Steinberg, 2014; LaFontana & Cillessen, 2010), one would imagine spending more hours in synchronous class sessions on videoconference (with webcam on) may be stressful, uncomfortable, and distracting for the adolescents in this study. Yet the lack of evidence regarding "bad" ERT as well as null associations between *Zoom-heavy* ERT and adolescents' adjustment in this study may also be due, in part, to the relatively short time that students in the sample had spent learning remotely before survey administration (only two months). Further, students in the sample on average reported spending only 1 hour per day on average in synchronous class sessions, which may have skewed these results as this is a relatively small portion of their day. Perhaps if *Zoom-heavy* or *Chaotic* ERT experiences became

chronic, or if the sample spent a greater number of hours in synchronous class sessions on average, the gap between experiencing more effectively engaging ERT (*Teacher transitional support, Heavy social load,* and *Heavy workload* ERT) versus not engaging ERT (*Zoom-heavy* and *Chaotic* ERT) may have become evident among adolescents' academic outcomes and affect. In this study, *Zoom-heavy* ERT did emerge as a common occurrence among high school students' remote learning experiences even at the onset of the COVID-19 pandemic. As many students were still learning remotely at the start and throughout the next school year (2020-2021) as well, there was ample opportunity for these experiences to continue.

Relative importance of home, individual, and ERT experiences post-transition

While the primary focus of this study was to identify ERT experiences predictive of adolescents' academic and emotional adjustment after shifting from in-person to remote learning, it important that ERT's influence on these outcomes are weighed relative to other individual and home environmental factors that occurred in adolescent students' lives during this time. In the subsequent paragraphs, the interplay between adolescents' home and school lives and its influence on students' academic and emotional adjustment at the onset of the COVID-19 pandemic among the sample are discussed.

The findings of this study reveal differences between students, their home environments, and ERT experiences each contributed to differences in adolescents' engagement while learning remotely at the onset of the COVID-19 pandemic. Yet, with respect to their happiness, enjoyment of and hopefulness about life (i.e., positive affect), only differences in students' daily perceptions, routines, and home lives explained significant variance in this outcome. In other words, ERT was a strong predictor of adolescents' academic adjustment, but not similarly predictive of their emotional adjustment during this time. There is a confluence of factors

occurring at the onset of crises (such as a pandemic) that are known to be more impactful than others on adolescent engagement and psychological distress respectively (Drane et al., 2020). In this study, adolescents' perception that it was harder to learn remotely than to learn in person (*perceived difficulty learning remotely*) was the strongest predictor of students' engagement post-transition, over and above other individual and home-level factors. Studies find K-12 students generally prefer traditional, face-to-face classes more than their online classes during the pandemic (e.g., Yan et al., 2020) as well as report being less motivated while learning remotely compared to when they were learning previously in-person (e.g., Corpus et al., 2022; Usher et al., 2021). This study directly linked adolescents' perception that it was more difficult for them to learn remotely to both negative outcomes of this study – their lower level of engagement and positive affect after transitioning to learning remotely. This was after inclusion of a variety of other ERT, home, and individual-level factors into the models which aimed to control for disparities in student's technological capability, confidence, and resources.

Home-level factors explained 13% of the variance in students' post-transition engagement and 6% of the variance in post-transition affect. Having someone at home who talked to them about their schoolwork and helped them with their schoolwork positively predicted greater engagement post-transition, however, students reported being significantly less engaged the more frequently they had to deal with intrusions and distractions from siblings and others in their household. Both home support and frequency of home distractions included statements aimed at ascertaining the availability of support and level of interest and involvement from others at home in supporting students' success in learning remotely. Distractions by their very nature prevent the focus and persistence with schoolwork endemic to engagement (Vahedi et al., 2019; Sana et al., 2013). However, distractions from siblings and/or others at home might

have had both positive and negative consequences on adolescents' positive affect (i.e., welcome vs. unwelcome distractions from a siblings/others), thus negating any general association with positive affect that would have been captured here.

Of the four home-level covariates included in the model, only greater *frequency of Wi-Fi/internet connectivity problems* was associated with adolescents' lower positive affect post-transition. That is, frequent problems with internet connectivity at home predicted adolescents' less frequent happiness, enjoyment of and hopefulness about life post-transition. This is interesting, as there are more obvious academic repercussions for students who have poor at-home internet connectivity while learning remotely/online. The inability to participate in learning activities and connect with their teachers and peers at the same capacity as other students is likely frustrating and may be demoralizing to students' enthusiasm for learning, especially during adolescence when students are particularly tuned in to their peers' perceptions of their academic competence (Wentzel, 1998). However, perhaps poor internet connectivity has more *social* repercussions than academic ones for adolescents. While remote learning, adolescents with unstable Wi-Fi likely stood out during synchronous class sessions among their peers via their constant logging in and out, their teachers' attention to making sure they were there, and/or awkwardness or inability to participate in activities that required greater bandwidth. Lack of Wi-Fi connectivity likely also infringed on youth's ability to socialize with others virtually. Thus, the social consequences which stem from students having poor Wi-Fi / internet connectivity at home may have relevant repercussions for youths' positive affect during this time and particularly at this stage of development.

2.6 Strengths and Limitations

This study identifies ERT experiences associated with adolescents' greater engagement and positive affect two months after transitioning from in-person to learning remotely. As such, the findings best reflect effective ERT in direct answer to an emergency (where there is little time to plan or prepare a sequence of learning) and may not reflect online/remote teaching and learning practices which better engage students after a prolonged period of remote learning (e.g., mid- or late-pandemic) or in well-prepared online learning programs and/or virtual academies. Recent research finds there are qualitatively different responses to early and mid-pandemic circumstances (Ravens-Sieberer et al., 2021; Elmer et al., 2020), which suggests there are different mechanisms underlying adolescents' adjustment at different phases of the pandemic. Likewise, it is still an open question as to how and whether these findings reflect effective practices in K-12 online education, as ERT differs from online education (e.g., virtual K-12 academies) in teachers' level of preparation, the learning goals, and expected participation and requirements of the learners (Hodges et al., 2020; Barbour & LaBonte, 2017; Molnar et al., 2019). This study also did not account for the online teaching infrastructure in place to help support students' online learning in the school surveyed for this study (e.g., their teachers' level of preparation, professional development available, and other school supports), thus their influence on students' engagement and affect in this study are underrepresented. Future research could better elucidate which ERT pedagogical and instructional strategies effectively promote students' academic and emotional adjustment at different time points throughout the pandemic and/or over different lengths of time while learning remotely, as well as identify whether effective ERT strategies and infrastructures are equally effective in fully online education course structures.

One of the strengths of this study is that it compares ERT which integrates technology in different capacities into students' learning to students' perceived engagement levels (Schindler et al., 2017). For instance, *Zoom-heavy ERT*, a mostly synchronous learning experience, was not predictive of adolescent students' higher or lower engagement while learning remotely, contrary to prior studies which suggest synchronous class sessions are more so engaging for students (e.g., Nyguyen, 2020). However, a limitation of this study is that it does not investigate, nor does it identify, emergency remote teaching practices, lesson plans, and activities on a granular level. The aim of this study was to identify common ERT experiences among high school students at the onset of the pandemic, and the current study's focus on broader structural considerations – such as number of hours spent on synchronous vs. asynchronous tasks – likely missed important nuances, such as specific synchronous and asynchronous lesson plans, activities, or teaching practices which are more or less engaging for students.

Due to exclusive use of student self-reports, the findings of this study are more prone to social desirability bias. While adolescents are fully capable of reporting their own psychological distress (Smith, 2007), parallel reports from teachers and/or parents may have provided more balanced views regarding the teaching practices and learning experiences students were assigned and participated in at the start of COVID-19-related remote learning. However, while teachers' and parents' reporting often parallel student's own, recent studies conducted during the COVID-19 pandemic find student and teacher reports measurably differ regarding what student's remote learning entailed during this time (e.g., Fabriz et al., 2021). Thus, a multi-informant approach may not have provided more accurate depictions of students' remote learning experiences so much as reporting from the students themselves.

Although this study assesses (and controls for) students' level of engagement and positive affect while previously learning in-person, students were asked to think back two months prior to report their pre-transition engagement and affect. Asking students to think back to how they used to feel compared to how they feel now, especially regarding feelings before and after a traumatic historical event such as a pandemic, may have biased these estimates due to contrast and recency bias (Schwarz et al., 2008). Further, student's estimates could have been influenced by their current difficulty learning remotely (Molnar et al., 2019; Muilenburg & Berge, 2005) and/or preference for learning in-person (Redpath, 2012). However, use of a set timeline for students to guide students' thinking about their experiences ("*BEFORE and AFTER transitioning to learning remotely*") should help mitigate some of this bias.

The present sample of fairly affluent and mostly White high school students is informative for this subset of the population but is not representative of adolescent students' experiences in general during this pandemic. The COVID-19 crisis has disproportionately hurt socioeconomically disadvantaged students and families (Lederer et al., 2020; McKune et al., 2021; Rudenstine et al., 2020) and communities of color (Webb Hooper et al., 2020) and it is critical that future studies include more diverse samples to begin to understand their experiences. Further, this study could unfortunately not account for students' socioeconomic status. A sudden shift from in-person to remote learning may have put students from more and less advantaged and disadvantaged backgrounds at differing levels of risk for academic disengagement and emotional maladjustment post-transition (Drane et al., 2020). In this study, covariates are included which assess students' level of support at home and the frequency with which student's reported experiencing problems with their Wi-Fi/internet connectivity and devices at home as well as their digital literacy skills. There is some evidence that digitally skilled students are more

likely to come from materially resourced backgrounds (e.g., Warschauer & Matuchniak, 2010) and thus, these may act as proxy measures for students' SES in this study.

While a strength of this study is that it provides a holistic description of students' lives in the initial aftermath of the COVID-19 pandemic through an investigation of and accounting for a variety of individual-level, home environment, and ERT experiences, there are almost certainly other factors and circumstances occurring in student's lives during this time that were likely impactful for students' engagement and affect as well. For instance, experiencing the death of a loved one or family member, anxiety over one's own health, as well as time spent using social media have all been linked to adolescents' poorer engagement and psychological well-being throughout the COVID-19 pandemic (e.g., Ellis et al., 2020; Wang et al., 2022a). Although this study is able to explain 57% and 52% of the variance in post-transition engagement and positive affect respectively among the adolescents in the sample, I extend the call for future research which considers and identifies the other half of this puzzle.

2.7 Conclusion

Emergency remote teaching (ERT) has become a staple of K-12 education during times of crisis, yet there is little guidance regarding ERT practices which more so engage or support students emotionally after a sudden shift to remote learning. As adolescents are an already an at-risk population for academic disengagement and psychological distress, this study sought to identify ERT strategies which better supported this student population post-transition. Principal components analyses identified 5 patterns among the ERT students experienced: *Teacher transitional support, Zoom-heavy, Heavy workload, Chaotic,* and *Heavy social load*. ERT experiences characterized by high levels of teacher support (i.e., communication of care for student well-being, provision of clear rules and expectations for remote work, and interesting

work) were associated with adolescents' higher level of engagement as well as their more positive affect post-transition. Further, provisioning of greater opportunities to interact with peers, greater variety of online learning activities, and an even balance of synchronous to asynchronous hours were each associated with adolescents' higher levels of engagement post-transition. The findings of this study can be used to help guide middle and high school educators' decisions and efforts to shift their in-person course online if/when they need to.

Table 2.1 *Correlation matrix from PCA of ERT Experiences*

		Component				
		1	2	3	4	5
Measure	Mean	Teacher transitional support	Zoom-heavy	Heavy workload	Chaotic	Heavy social load
Daily hours spent in live class sessions[1]	1.48	-0.09	**0.67**	**0.59**	-0.13	0.00
Daily hours spent on asynchronous activities[1]	3.67	-0.04	**-0.68**	**0.53**	-0.27	0.05
Perceived quality of live class sessions	-.15	0.24	**-0.54**	**-0.70**	0.08	0.05
Perceived quality of asynchronous activities	-.43	0.00	**0.69**	**-0.45**	0.30	0.26
Variety of online learning activities	4.04	**0.46**	-0.12	0.14	**0.57**	**-0.50**
Variety of offline learning activities	.70	0.22	-0.15	**0.48**	**0.64**	0.30
Teacher communication of care	3.62	**0.79**	0.13	0.06	-0.03	**-0.38**
Teacher made the work interesting	2.84	**0.77**	0.17	-0.06	-0.28	-0.07
Teacher clarity of rules and expectations	3.91	**0.74**	0.11	0.02	**-0.34**	0.21
Opportunities for academic peer interaction (post-transition)	2.37	**0.54**	-0.13	0.10	0.10	**0.67**

[1]Students were asked to report the number of hours they spent during "a typical day of remote learning".

Note. PCA loadings are from correlation matrix with eigenvalue > 1. PCA loadings > 0.3 are indicated in bold. All variables were standardized before inclusion in the PCA. Means were taken from the unstandardized versions of these variables.

Table 2.2 *Means and Correlations between All Study 1 Variables*

Measure	*Mean*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
1. Comp 1: Teacher Transitional Support	0.00	1.0																						
2. Comp 2: Zoom-Heavy	0.00	.00	1.0																					
3. Comp 3: Heavy Workload	0.00	.00	.00	1.0																				
4. Comp 4: Chaotic	0.00	.00	.00	.00	1.0																			
5. Comp 5: Heavy Social Load	0.00	.00	.00	.00	.00	1.0																		
6. Grade	10.36	-.05	**.33****	-.11	-.11	-.11	1.0																	
7. Gender	1.40	-.05	.17	**-.28****	.08	-.04	.05	1.0																
8. Engagement (pre-transition)	3.82	.17	-.01	**.20***	-.11	-.11	-.05	-.02	1.0															
9. Engagement (post-transition)	2.99	**.47****	-.05	.12	-.17	**.26****	-.03	-.11	.18	1.0														
10. Positive affect (pre-transition)	3.20	.09	.15	-.01	-.11	-.09	.02	.01	**.48****	-.04	1.0													
11. Positive affect (post-transition)	2.74	**.34****	.14	-.05	-.09	.17	.04	.01	.11	**.33****	**.47****	1.0												
12. Daily hours spent sleeping	8.15	**.20***	-.05	-.12	.17	.01	-.02	-.12	-.04	.04	.03	.11	1.0											
13. Daily hours spent socializing with friends online/virtually	3.20	.04	.02	-.09	.08	.13	-.03	.07	.05	-.05	.08	.04	.03	1.0										
14. Daily hours spent exercising/going outside	2.56	.14	.03	-.05	-.10	-.05	-.06	.02	-.01	-.09	.03	.14	-.03	-.08	1.0									
15. Daily hours spent doing something that you enjoy	3.68	.06	-.06	-.13	.10	.11	.00	.08	-.09	.00	-.09	-.05	-.03	-.08	-.10	1.0								
16. Daily hours spent taking care of home responsibilities	1.70	-.01	-.12	-.04	.00	.11	.05	-.07	**-.18***	-.09	-.17	-.03	**-.17***	.02	**.20***	.01	1.0							
17. Frequency of WiFi/internet connectivity problems	1.83	-.14	.02	.04	-.01	-.08	-.01	-.14	-.13	**-.23***	-.08	**-.29****	.00	-.09	-.04	-.15	**.23****	1.0						
18. Frequency of home distractions (siblings and/or others)	2.75	-.17	-.13	.14	-.06	**-.18***	-.16	-.09	.07	**-.41****	.03	**-.23***	-.07	-.04	.05	.03	.17	**.22***	1.0					
19. Frequency of device problems	1.89	**-.22***	-.08	.05	.14	.00	-.07	-.16	-.13	**-.23***	-.01	-.07	-.05	-.02	-.05	-.05	**.24****	**.41****	**.24****	1.0				
20. Home support	2.79	**.37****	-.02	-.08	**-.22***	.14	-.10	-.17	.04	**.33****	.13	**.30****	.08	.12	.04	.10	-.01	**-.18***	-.07	-.14	1.0			
21. Competence using webtools	4.07	**.37****	.01	-.02	**-.35****	.00	**.21****	.03	.09	**.31****	.01	**.19***	.05	.11	.08	.10	.02	**-.27****	**-.24****	**-.45****	**.28****	1.0		
22. Perceived difficulty learning remotely	2.08	**-.21***	-.16	.13	.12	-.15	**-.17***	-.07	**.21***	**-.41****	.08	**-.38****	-.15	-.05	.05	-.05	.08	**.25****	**.40****	**.24****	-.12	**-.41****	1.0	
23. Opportunities for academic peer interaction (pre-transition)	2.37	**.54****	-.13	.10	.10	**.67****	-.16	-.01	-.02	**.39****	-.04	**.26****	.09	.15	.03	.12	.04	-.14	-.18*	-.16	**.24****	.15	**-.19***	1.0

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 2.3. *Summary of Regression Results: High School Students' Engagement after Transitioning from Learning in Person to Learning Remotely during COVID*

	β	*p*	*tolerance*	*VIF*	
Step 1. Individual-level covariates					
Gender - Female	-.126	.143	.896	1.12	
Grade	-.158	.078	.820	1.22	
Engagement (pre-transition)[1]	.251**	.004	.873	1.15	
Perceived difficulty learning remotely	-.413***	<.001	.726	1.38	
Competence using webtools	.208*	.030	.723	1.38	
Daily hours spent sleeping	-.016	.854	.896	1.12	
Daily hours spent socializing virutally with friends	-.117	.163	.937	1.07	
Daily hours spent doing something by yourself that you enjoy	-.021	.806	.905	1.11	
Daily hours spent exercising or going outside	-.081	.338	.910	1.10	
Daily hours spent taking care of responsibilities at home	.028	.748	.853	1.17	
Opportunities for academic peer interaction (pre-transition)	-.057	.514	.860	1.16	
					$R^2 = .320$
					$\Delta F = 4.50$***
Step 2. Home environment covariates					
Frequency of WiFi/internet connectivity problems	-.022	.799	.722	1.39	
Frequency of home distractions from siblings and/or others	-.288**	.001	.751	1.33	
Frequency of device problems	-.035	.702	.673	1.49	
Home support	.255**	.002	.839	1.19	
					$\Delta R^2 = .125$
					$R^2 = .445$
					$\Delta F = 5.66$***
Step 3. ERT experiences					
Comp. 1: Teacher transitional support	.336***	<.001	.696	1.44	
Comp. 2: Zoom-heavy	-.103	.197	.704	1.42	
Comp. 3: Heavy workload	.162*	.040	.612	1.64	
Comp. 4: Chaotic	-.084	.318	.632	1.58	
Comp. 5: Heavy social load	.165*	.039	.804	1.24	
					$\Delta R^2 = .126$
					$R^2 = .571$
					$\Delta F = 5.68$***

[1]Engagement pre-transition (individual-level covariate) was measured at the same time point as engagement post-transition (dependent outcome). Students responded to 6 statements in May 2020 twice, once in reference to how they had felt before COVID (while learning in person two months prior), then responded to the same statements again but in relation to how they felt currently (while learning remotely).

Note. "*'$p < .05$; '**'$p < .01$; '***'$p < .001$.

Table 2.4. Summary of Regression Results: High School Students' Positive Affect after Transitioning from Learning in Person to Learning Remotely during COVID

	β	*p*	*tolerance*	*VIF*
Step 1. Individual-level covariates				
Gender - Female	-.035	.653	.889	1.13
Grade	-.030	.704	.837	1.19
Positive affect (pre-transition)[1]	.494***	<.001	.902	1.11
Perceived difficulty learning remotely	-.428***	<.001	.750	1.33
Competence using webtools	.034	.683	.769	1.30
Daily hours spent sleeping	.041	.598	.898	1.11
Daily hours spent socializing virutally with friends	-.006	.942	.929	1.08
Daily hours spent doing something by yourself that you enjoy	-.056	.469	.898	1.11
Daily hours spent exercising or going outside	.182*	.019	.899	1.11
Daily hours spent taking care of responsibilities at home	.069	.379	.856	1.17
Opportunities for academic peer interaction (pre-transition)	-.002	.977	.863	1.16
				R^2 = .430
				ΔF = 7.42***
Step 2. Home environment covariates				
Frequency of WiFi/internet connectivity problems	-.185*	.022	.770	1.30
Frequency of home distractions from siblings and/or others	-.116	.132	.828	1.21
Frequency of device problems	.129	.123	.705	1.42
Home support	.140	.074	.811	1.23
				R^2 = .494
				ΔF = 3.24*
Step 3. ERT experiences				
Comp. 1: Teacher transitional support	.160*	.050	.726	1.38
Comp. 2: Zoom-heavy	.008	.926	.712	1.41
Comp. 3: Heavy workload	-.026	.759	.648	1.54
Comp. 4: Chaotic	.005	.954	.618	1.62
Comp. 5: Heavy social load	.128	.099	.810	1.23
				R^2 = .524
				ΔF = 1.28

[1]Positive affect pre-transition (individual-level covariate) was measured at the same time point as positive affect post-transition (dependent outcome). Students responded to 3 statements in May 2020 twice, once in reference to how they had felt before COVID (while learning in person two months prior), then responded to the same statements again but in relation to how they felt currently (while learning remotely).

Note. "*'p < .05; '**'p < .01; '***'p < .001.

Chapter 3 – Webcams On or Off? A Multi-level Analysis of Students' Webcam Use in Virtual Classes Respective to Their Engagement in Learning and End-of-Year Achievement

3.1 Abstract

Virtual classes hosted via videoconferencing platforms have become commonplace in K-12 education when teachers and students cannot meet in person, yet surveys find children and adolescents prefer to keep their webcams off during these sessions. The present study identifies multi-level determinants of students' webcam use among a sample of 1,426 elementary school students nested within 62 classrooms (49% male, 93% White, M_{grade}= 4.2) and further uses multi-level modeling to identify whether differences between students' and classrooms' webcam use uniquely predict students' end-of-year academic achievement over and above other forms of student engagement in learning (behavioral and emotional). In May 2021, students answered survey questions regarding their attendance and participation in virtual classes since May 2020 (i.e., over the course of the first school year of the COVID-19 pandemic). Student's' survey responses were linked with school-provided achievement data (MSTEP 2020-2021 mathematics and English subtest scores) and demographic data. Partial correlations revealed individual webcam use was negatively correlated with individual SES and non-binary gender identity, and positively correlated with individual behavioral and emotional engagement. Class-level webcam use was positively correlated with class-level emotional engagement, and negatively correlated

with classroom proportion of female students and average hours spent in virtual classes. Results of the multi-level models indicated classroom webcam use norms (i.e. differences in average webcam use between classrooms) explained significant variation in children's end-of-year academic achievement, however individual webcam use was not similarly predictive of end-of-year achievement after individual behavioral and emotional engagement were considered. The findings of this study suggest students' webcam use in virtual classes is only weakly related to their perceived behavioral and emotional engagement in learning, and further, that it varies from more traditional forms of engagement in its association with later academic achievement (i.e., predictive only at class-level and not at the individual-level).

3.2 Introduction

During the COVID-19 pandemic, students of all ages attended virtual classes through video-conferencing platforms (e.g., on Zoom or Google Meet). Attending class virtually provided youth with the opportunity to continue positive face-to-face interactions with teachers and peers even while socially distanced. Yet over time, students began choosing to keep their webcams off during these sessions (Day & Verbiest, 2021; Bedenlier et al., 2021; Reed, 2020; Will, 2020). Educators and parents alike debated whether to require students' webcam use during virtual classes (Will, 2020; Reed, 2020). K-12 school districts enacted different policies; most required students' webcam use, citing the necessity of visual and verbal participation in learning (Will, 2020). Others did not require students' webcam use, amid concerns requiring use would further exacerbate digital and social inequities in learning between students along socioeconomic and racial lines (Day & Verbiest, 2021) as well as concerns regarding student's privacy and younger student's public accessibility (Hosszu et al., 2021). The current study sought to help clarify this debate by investigating the relationship between the frequency that elementary school

students' and classrooms used their webcams in videoconference while learning remotely during the COVID-19 pandemic in relation to their self-reported behavioral and emotional engagement in learning. This study further delineates how each form of engagement (behavioral, emotional, and visual) is associated with students' end-of-year achievement via hierarchical linear modeling.

Studies seeking to define appropriate parameters for children and adolescents' device use in K-12 education settings are not new. Previous studies have examined student's achievement outcomes relative to whether their classroom banned their use of certain devices, the findings of which have helped inform the use of laptops and smartphones in elementary and secondary school classrooms (Elliott-Dorans, 2018; Hall et al., 2020; Zheng et al., 2016; Felisoni & Godoi, 2018). Others have compared student's achievement outcomes relative to whether they attended a course online or in-person (Xu & Jaggers, 2014; U.S. Department of Education, 2010) as well as whether adoption of one-to-one devices in K-12 schools related to any difference in students' achievement outcomes (Donovan et al., 2010).

Research on effective teaching practice in K-12 virtual school settings has existed for many years (Dipietro, 2010; Toppin & Toppin, 2015; Hampel & Hauck, 2004), yet currently, no studies of K-12 student's use of their webcam while attending synchronous class sessions and achievement outcomes exist. Past studies – conducted before the COVID-19 pandemic - of student's use of webcam in videoconferences in online courses almost exclusively assessed undergraduate students. More recent webcam use studies – conducted during the COVID-19 pandemic – are mostly qualitative, assessing students' perceptions and/or reasoning for keeping their webcam on or off, and do not tie reported webcam usage to educational outcomes (e.g., Castelli & Sarvary, 2021; Gherheș et al., 2021; Lawson et al., 2010; Bedenlier et al., 2021;

Hosszu et al., 2021). There have been a number of previous small-scale studies which have investigated K-12 student's learning via videoconference respective to their use of webcam in these sessions. These studies suffer from a lack of generalizability both due to their small sample size, as well as that they are centered within learning circumstances that are not generalizable to K-12 general education (e.g., online language learning, telehealth services, dyadic education, rural education: Develotte et al., 2010; Gilles, 2008; Codreanu & Celik, 2013; Rehn et al., 2018). In the wake of the pandemic, several frameworks have been proposed to help inform K-12 educators' decisions when shifting younger students online in an emergency (e.g., Moorhouse, 2020; Moorhouse & Wong, 2021; Neuwirth et al., 2020; Nguyen et al., 2021; Wang, 2021). None have yet provided suggestions for effective practice regarding K-12 students' use of webcams in these contexts.

Little is known regarding K-12 students' participation and engagement in virtual classes in general, specifically to what extent their learning is influenced (or distracted) by the frequency with which they are on camera. Yet elementary school students often attended virtual classes via videoconferencing platforms throughout the pandemic (Timmons et al., 2021), and most were *required* to keep their webcams on during this time. Nationally representative surveys conducted during COVID-19 emergency remote learning identify more than 75% of K-12 teachers, principals, and district leaders whose schools or districts provided live remote instruction required students' webcams be on while attending class via videoconference (EdWeek Research Center, 2020). While nearly half (42%) provided student exemption based on their preference, 17% had stricter rules and required student's keep their webcam on while in virtual classes unless their parents specifically requested exception. A further 18% required webcams be on, and permitted no exemptions (Will, 2020; EdWeek Research Center, 2020).

We currently do not know whether this participation is meaningful (or detrimental) to learning among this age group. Younger students are much different than undergraduate students developmentally. When learning online, younger students often lack the metacognitive skills needed to remain engaged in virtual class sessions, independently plan their learning, and/or converse with peers online in a meaningful way (Barbour, 2013; Huffaker & Calvert, 2003; Wang et al., 2013). There is also evidence synchronous online classes require a higher cognitive load of students and thus are more cognitively taxing for younger learners even without consideration of their additional use of webcam overtop of this (Barbour & Reeves, 2009). Increased acceptance of online teaching and learning formats in K-12 education as a result of the COVID-19 pandemic is likely to continue boosting demand for and integration of webcam-based courses in K-12 education in the future (Allen et al., 2016; Barbour & Reeves, 2009; Dhawan, 2020; Schwartz et al., 2020; Toppin & Toppin, 2015; Moorhouse & Wong, 2021). Understanding why children do or do not use their webcam, as well as whether their webcam use ties to their greater engagement in learning and/or later achievement outcomes when learning online is important to consider for future elementary educators' decisions regarding online course creation and development.

This study surveyed a large sample of elementary school students (children and early adolescents, grades 3-6) in May 2021, and collected quantitative data on their daily remote learning experiences and routines since March 2020 (when schools closed and students' remote learning began). Quantitative data was also collected on students' webcam usage, their behavioral and emotional engagement, alongside school-provided demographic and achievement data (i.e., MSTEP mathematics and English scores). The following sections review recent theory and findings regarding individual correlates and contextual supports for students' webcam use in

virtual classes, followed by a review of current studies that support a proposed relationship between students' webcam use in virtual classes, their levels of engagement as well as subsequent achievement in these courses. This review concludes with recent evidence that webcam use in virtual classes is influenced by both individual- and group-level processes.

3.2.1 Individual differences in webcam use

Students' preference and use of different learning technologies is influenced by their individual characteristics, their environment, as well as dependent upon the technological resources made available to them. Studies have identified differences in student's use of devices by their age and grade level (Gherheș et al., 2021; EdWeek Research Center, 2020), their gender (Bui et al., 2020; Armstrong-Stassen et al., 2006; Colley, 2003; Park & Kim, 2020), socioeconomic status (Yan et al., 2021; Koivusilta et al., 2007; Calvert et al., 2005; Rodrigues & Biagi, 2017), and available devices and technological resources at school (Rashid & Asghar, 2016; Felisoni & Godoi, 2018; Elliot-Dorans, 2018; Donovan et al., 2010). Further, studies have identified student's use of learning technologies can have polarized outcomes depending on the student population as well as the context where use is studied (Rashid & Asghar, 2016; Felisoni & Godoi, 2018).

Socioeconomic status is a consistent predictor of students' use of various learning technologies (Yan et al., 2021; Koivusilta et al., 2007; Calvert et al., 2005; Rodrigues & Biagi, 2017). Students who reside in socioeconomically disadvantaged households more often lack access to learning technologies as well as home supports for their remote learning; they may lack a private working space, have older computers at home that do not have and/or support the use of webcams, and/or have unstable WiFi connections and poor bandwidth at home that cannot reliably support videoconferencing (Rashid & Asghar, 2016; Felisoni & Godoi, 2018; Elliot-

Dorans, 2018; Donovan et al., 2010). Further, youth who live in disadvantaged households may not want to provide peers and teachers with a window into their lives; it may be embarrassing and uncomfortable to have others see inside their homes (Gherheș et al., 2020) and/or know their current location (e.g., in a car outside a local library or a parents' workplace connecting to Wi-Fi). Although it is often suggested that students embarrassed by their surroundings employ a virtual background to regain privacy, having older and out-of-date technology resources limit especially low SES students' ability to do so (Henry & Shellenbarger, 2020). Concern regarding their environment is a consistent reason provided by students of all ages as to why they choose to keep their webcams turned off (Castelli & Sarvary, 2021; Gherheș et al., 2021; Neuwirth et al., 2020). Prior studies and current qualitative evidence thus support the idea webcam use is psychologically and financially stressful for students from socioeconomically disadvantage backgrounds, which likely interferes with their ability as well as desire to visually engage during virtual classes.

Students' use of learning technologies and competency beliefs vary by their individual characteristics such as their gender, age, and racial-ethnic identity (e.g., Eccles et al., 1993; Colley, 2003; Calvert et al., 2005; EdWeek Research Center, 2020; Bui et al., 2020). Colley (2003) was one of the first studies to identify significant gender differences in K-12 students' use of school computers, whereby girls were generally more task-oriented in their use (typically used school computers to complete academic tasks and to communicate with others), while boys were more often play- or mastery-oriented in their school computer use (more often participated in computer gaming and attempted to circumvent restrictive access on their devices). As students age, the frequency they use technology in their learning as well as the complexity of their use increases (Calvert et al., 2005; Colley, 2003). Further, although there is lacking consensus

regarding the role of student racial-ethnic identity in use of learning technologies, during the COVID-19 pandemic, racial-ethnic group membership did appear to play a role in the likelihood that webcam use was required at the class-level: 31 percent of K-12 educators that required webcam use (no exceptions) were within districts where 30% or less of their student population was White. Only 15 percent of educators in districts with 80 percent or more of White students required as strict of student webcam use (EdWeek Research Center, 2020). Thus, individual differences are likely important for understanding how use of webcam is approached by students in various virtual learning settings but particularly when attending classes via videoconference, which may help explain differences in students' engagement in learning while learning online respective to their frequency of use.

Numerous studies conducted during the COVID-19 pandemic suggest how long students spent learning remotely and/or in virtual class sessions per day are likely environmental drivers that influenced their use of their webcam. Recent studies identify students and adults generally consider being on camera while in videoconferences with others to be stressful and when prolonged, draining (EdWeek Research Center, 2020; Blanchard, 2021; Yamada & Akahori, 2009). In a small-scale study of specifically university students, Yamada and Akahori (2009) found students did not like to always see themselves when attending webcam-based courses and often became self-conscious and uncomfortable when forced to be on camera for long periods of time. Overexertion that comes with extended periods of being on camera, looking at others, and navigating a videoconferencing interface, is commonly referred to as "Zoom fatigue" (Blanchard, 2021), so named due to the most popular videoconferencing platform utilized during the COVID-19 pandemic (i.e., Zoom). Seeing one's face, alongside that of all of one's peers, is likely an especially emotionally precarious (and draining) situation for elementary and middle

school students. Neurological development in areas of the brain that ascertain others' thoughts and opinions during early adolescence (e.g., around ages 10-13) increase older elementary school student's ability to perceive peers' positive judgments of them as individuals. As such, positive peer judgements and self-presentations dramatically increase in importance for youth's self-image (Steinberg, 2014; LaFontana & Cillessen, 2010). Among K-12 student surveys on webcam use conducted during COVID-19 emergency remote learning, K-12 students consistently cite less frequent judgement from peers as a primary reason they did not use their webcam during this time (e.g., EdWeek Research Center, 2020).

Educational outcomes of students' webcam (non)use may be due to the societal conditions these students encounter, and not just their use (Neuwirth et al., 2020). Studies of students' webcam use respective to their educational outcomes should consider students' SES, the time they have spent learning remotely, as well as the time they have spent attending virtual classes, as each may explain differences between students in the frequency with which they use their webcam.

3.2.2 Students' webcam (non)use and engagement

Engagement is defined as behaviors indicative of student's internal motivation to succeed in school or on schoolwork (Wang & Degol, 2014). Most theories in educational psychology and education technology research conceptualize engagement as a multidimensional construct that includes at least a behavioral and emotional component within it, each interrelated yet also uniquely predictive of students' later academic achievement (Wang & Eccles, 2012; Fredricks et al., 2011; Martin & Borup, 2022; Sinatra et al., 2015). *Behavioral engagement* is students' visible and/or active participation and effort in class (e.g., attention, participation in class discussion), while *emotional engagement* is students' positive emotions regarding learning

and/or schoolwork (i.e., level of interest and enjoyment in what they are learning, Fredricks et al., 2004). Higher levels of engagement are associated with students' improved learning (Wigfield et al., 2008), higher standardized test scores and grades (Skinner et al., 1990), and higher educational aspirations and attainment (Cornell et al., 2016). Engagement is of particular interest to the education research community as it is indicative of achievement yet still responsive to changes made to learning environments (Christenson et al., 2012; Fredricks, 2015; Fredricks et al., 2004). For example, student's increasingly positive experiences with peers in their classroom – such as having made new friends and gaining peer acceptance – are consistently predictive of subsequent increases in student's classroom engagement (Engels et al., 2017; Ladd et al., 1990; Ryan et al., 2019).

The extent to which student (non)use of webcam during synchronous class sessions is denotive of their level of engagement in learning remains an open question, as no study has yet compared students' use of webcam in virtual classes to an established measure of engagement (i.e., behavioral or emotional engagement). Some qualitative evidence exists which suggests student's webcam use and engagement in learning are interrelated. In a study of 40 undergraduate students, Yamada & Akahori (2009) found students use of webcam in an economics course better maintained their attention to course content and instruction than when students watched with webcam off (i.e., higher *behavioral engagement*). Another study which collected interviews from 36 undergraduate pre-service teachers found those who identified themselves as frequent webcam users while in virtual classes reported feeling more involved in learning (i.e., higher *emotional engagement*) (Candarli & Yuksel, 2012). Yet it is important to note these studies each utilize very small sample sizes (<50), and thus the generalizability of their findings to other students is questionable and not recommended.

Conversely, quantitative studies do not find an association between student's webcam use and level of engagement (e.g., Roth & Gafni, 2021, Händel et al., 2022; Giesbers et al., 2013). Roth & Gafni (2021) assessed undergraduates' webcam use in virtual classes during emergency remote learning and identified it was not concurrently associated with their more positive academic emotions (enjoyment, hope, and pride, i.e., *emotional engagement*). Giesbers et al. (2013) found that within a summer course in economics for undergraduate students (before the pandemic), the more frequently students used videoconference tools (which included webcam, audio, and text box use) was not associated with self-reported higher intrinsic motivation.

These seemingly conflicting findings may be due, in part, to the differing level of autonomy students are given across learning contexts to keep their webcam on or off during virtual classes. Most theories of engagement build on the assumption that students must meaningfully and *willingly* engage in academic tasks for learning to occur (for review, see Fredricks et al., 2004). Quite often, webcam use during COVID-19 emergency remote learning violates this assumption; some students were required to use their webcam, others were required unless exempt, and still others were able to choose to keep their webcam on or off depending on their own personal preference (EdWeek Research Center, 2020). Variable affordances for student choice in webcam use may result in its relatively weak association with measures of student engagement. This may be especially true among elementary school students, for whom webcam use was more frequently required (EdWeek Research Center, 2020).

Webcam (non)use, social presence, and student engagement

There is consensus that webcam use increases social presence in virtual classes thus promotes engagement. Social presence pertains to feeling "real" in a virtual space; having authentic and genuine conversations with others, seeing others facial expressions, responding in

kind, all of which contribute to the social-emotional climate and feeling of togetherness occurring within a learning environment (for review, see Oh et al., 2018). When all students in a virtual classroom keep their webcam on, studies find it sponsors a sense of togetherness and a sense of community among course participants in a virtual space (Blanchard, 2021; Di Blas & Poggi, 2007; McBrien et al., 2009).

Recent quantitative studies do find a modest positive association between undergraduates' frequency they used their webcam and perceptions of their virtual classroom's climate while learning online during the pandemic, specifically more frequent webcam use was associated with reporting a more openly communicative classroom atmosphere (Händel et al., 2022). Many studies of in-person learning find feeling a sense of connectedness with teachers and peers at school is a protective factor for youth of all ages, associated with increases in students' liking of and attendance at school, their motivation to achieve academically, as well as their engagement and achievement (Quin, 2016; Roorda et al. 2011; Furrer & Skinner, 2003; Wang & Eccles, 2012; Ryan, 2000; Zimmer-Gembeck et al., 2006; Patrick et al., 2007; King, 2015).

Constraints on students' ability to verbally engage while in virtual classes likely further increase the importance that students visually engage with webcam (McBrien et al., 2009; Ng, 2007). Generally, virtual classes hosted via videoconferencing platforms afford more numerous opportunities for student engagement than traditional in-person learning settings. In virtual classes, students can engage with differing levels of involvement via multiple modalities; they can visually engage (e.g., via webcam), verbally engage (e.g., aloud, or via chat box), or without offering visual or verbal input (e.g., via raising a virtual hand, or anonymously via class polls) (Platt et al., 2014). However, verbal communication is often restricted in virtual class settings, as

students either mute themselves or are muted by their teachers to avoid interruptions and distractions to other students (McBrien et al., 2009; Ng, 2007). Scholars note the challenges of lack of body language and of depersonalization of communication in virtual class settings where only audio and/or text-based communication is available (Boyle et al., 1994; Hampel & Hauck, 2004; Kress & van Leeuwen, 2001). Some studies have identified uses of technologies that impede verbal interaction with others (e.g., using a smartphone) are linked to surrounding other's discouragement and disengagement (e.g., Abeele et al., 2019). Likewise, studies find that when students cannot see each other, group and/or whole class discussions become stilted; they become characterized by long silences, shorter responses, and overlapping exchanges (Boyle et al., 1994). Students' non-use of their webcams could then have a dramatic effect on individual engagement and the engagement of the class as a whole if students feel engaging is awkward and/or uncomfortable.

Students' engagement in virtual classes is also not likely well facilitated if instructors feel they are talking to a wall of black boxes (Flanigan & Babchuk, 2022; Mastel-Smith et al., 2015). Web cameras build teacher-student relationships through the benefit of seeing students' faces, yet seeing their faces also allows teachers to assess the efficacy of their teaching in real-time (e.g., via student's smiles, grimaces, confused looks or looks of comprehension). Thus, teachers can quickly shift their instruction or examples to what their students might find easier to understand and/or more so engaging if they can see their faces (Flanigan & Babchuk, 2022). Other small-scale studies have noted that when teachers cannot see their students faces and/or body language in a virtual classroom, it appears to ease the social pressure students typically feel to participate within that space, allowing students to sit quietly and not seek out academic help when they need it and otherwise avoid interacting with others (Hampel & Hauck, 2004).

Webcam (non)use, academic distraction, and student engagement

Students' non-use of webcams in virtual classes also provides opportunities for multi-tasking and academic distraction (Hall et al., 2020; Sana et al., 2013; Vahedi et al., 2019). When students keep their webcams off, off-task behaviors are likely better facilitated as these behaviors become invisible (and unknowable) to teachers and peers. Studies consistently link students' off-task laptop behaviors during class time to disengagement as well as worse course outcomes (e.g., Vahedi et al., 2019; Sana et al., 2013). Further, multiple studies have demonstrated students who are simply *in view* of other students participating in off-task behaviors during class time can distract their learning enough such that it has academic repercussions (Sana et al., 2013; Hall et al., 2020). Sana and colleagues (2013) seated confederate research participants in various locations within an undergraduate lecture hall where they proceeded to engage in either on-task or off-task activities on their laptops in view of other students (i.e., taking notes, surfing Facebook, respectively). Upon assessing final course exam grades and outcomes, the researchers found course performance was markedly worse among students seated near off-task confederates, and markedly better among those seated near on-task confederates. Thus, while students' non-use of webcam in virtual classes likely greatly conveniences individual off-task behavior, widespread *use* of webcams in virtual classes where students are often off-task may also provide opportunities for academic distraction via students constantly in view of other students' faces, surroundings, and behaviors. Thus, webcam use may present a Catch-22 for facilitating greater engagement or disengagement among youth.

Previous research examining the effects on student engagement of increased opportunities for academic distraction from digital devices finds student self-reports are often unreliable indicators regarding a specific technology's impact. Undergraduate students tend to

overestimate their ability to multitask while using learning technologies in class; even when researchers inform them of the negative effects of media mulit-tasking on achievement, undergraduates continue to multitask anyway (Ophir et al., 2009; Kirschner & Bruychkere, 2017). Younger students have even less mature self-regulatory abilities than undergraduate students (Steinberg, 2014; Casey & Caudle, 2013). Recent research also casts doubt on younger students' ability to identify when they are distracted from learning (for review, see Kirschner & Bruychkere, 2017). As such, elementary school students appear both more vulnerable to webcam distractions when learning online yet also less reliable informants as to how often they are distracted by their webcam and its effect on their engagement (Pattermann et al., 2022; Kirschner & Bruychkere, 2017). Thus, in conjunction with the study aim to identify the association between younger student's webcam use and level of engagement when learning online, this study further compares how each are associated with achievement (i.e., MSTEP state achievement test score) to clarify how and whether webcam use uniquely is associated with a related yet objective educational outcome.

3.2.3 Level of Analysis Problem – Class-level Webcam Use

To this point, this study's review of the literature has focused primarily on students' decision to use their webcam during virtual classes. Yet, this decision does not occur in a vacuum; recent studies find webcam use differs between students but also between classrooms, as students conform to the norm of webcam use of the peers in their class (Castelli & Sarvary, 2021; Händel et al., 2022). Among undergraduate students, Händel and colleagues (2022) found significant indirect effects such that the relationship between virtual class size and student's individual webcam use was mediated by the average webcam use of course participants. In

addition, the relationship between their teacher's encouragement of webcam use and students' own frequency of webcam use was mediated through average webcam use of course participants.

Surprisingly, very little research has explored classroom-level webcam use and associations with students' individual learning outcomes. Prior work consistently finds shared classroom experiences influence students' individual educational outcomes, notably, their behavioral engagement (Ruzek et al., 2016), and achievement (Urdan & Midgley, 2003). Further, the prevalence with which K-12 teachers and principals required webcam use during virtual classes (EdWeek Research Center, 2020) suggests the effects of classroom-level webcam use on K-12 students' educational outcomes is perhaps more reasonable to assess than students' individual webcam use on these outcomes. That is, in classrooms where webcam use is required, associations between individual webcam use, engagement, and achievement become more likely due to student circumstances which allow their exemption (i.e., circumstances immutable from a policy perspective e.g., student SES). Examining webcam use in a multilevel context further allows for the exploration of a cross-level interaction that would confirm this hypothesis; if significant, it confirms in classrooms where students' always use their webcam (and/or use is required), individual-level webcam use becomes less predictive of students' engagement and achievement.

3.2.4 Current Study

The present study investigated elementary school students' frequency with which they used their webcam while videoconferencing in virtual classes respective to their level of behavioral and emotional engagement as well as academic achievement. Four main research questions are examined: First, it was of interest to identify characteristics of students and classrooms that were associated with specifically children's more frequent use of their webcam

to provide a basis through which to understand this age group's webcam use and participation when learning online *(RQ1)*. I begin by identifying correlates of webcam (non)use by student demographics (e.g., SES, gender, grade-level), individual perceptions (i.e., behavioral and emotional engagement), alongside shared characteristics and perceptions of their classroom learning environments (e.g., SES of their classroom). I hypothesize individual SES, gender, and racial/ethnic identity will correlate with students' webcam use frequency, in line with the findings of past studies of students' device use (e.g., Calvert et al., 2005; Colley, 2003; Rodrigues & Biagi, 2017) as well as demographic differences identified by COVID-19 remote learning student surveys (Day et al., 2020; Neuwirth et al., 2020; EdWeek Research Center, 2020). I further hypothesize demographic characteristics of students when pooled at the class-level (e.g., class mean SES) will correlate with individual webcam use, as students will likely adapt their webcam use to the norm of their class (Berndt, 1979; Händel et al., 2022). Second, I consider whether students' webcam use is related to other forms of student engagement: specifically, whether it is a related to students' behavioral and emotional engagement. I expect students' webcam use will exhibit a significant yet relatively weak correlation with students' behavioral and emotional engagement; This is because classroom webcam use norms likely heavily influence students' choice to use their webcam, which in turn, decreases its association with students' engagement (i.e., a willful action). There are also mixed findings regarding their association; quantitative studies do not find strong evidence of a relationship between the two (Händel et al., 2022; Roth & Gafni, 2021) yet small-scale qualitative studies do find a link (Yamada & Akahori, 2009). Taken together, this suggests their relatively weak association with one another, if one exists at all. Thirdly, using multi-level modeling, I examine variation in individual- and class-level webcam use and whether it explains additional variation in children's

individual achievement over and above variation in their individual and class-level engagement. There are contradictory findings between small-scale qualitative and large-scale quantitative studies of webcam use in relation to students' academic perceptions, engagement, and outcomes (Roth & Gafni, 2021; Yamada & Akahori, 2009; Giesbers et al., 2013; Händel et al., 2022). Thus, the hypotheses of this study are largely exploratory regarding the effects of individual- and class-level webcam use upon objective achievement. Finally, I test for a moderating effect of classroom-level webcam use. I predict inclusion of a cross-level interaction term between individual and class-level webcam use onto the outcome of achievement will be significant, as the relationship between individual webcam use and achievement may be best explained through consideration of the webcam use among their class as a whole (Berndt, 1979; Händel et al., 2022) (see Figure 1 for overview).

3.3 Methods

3.3.1 Participants

Survey participants were 1,575 3rd-6th grade students from 12 elementary schools in the Midwestern United States. The mean age among students was 9.2 years old (SD = 4.5). 31% were 3rd graders, 37% were 4th graders, 30% were 5th graders, 4% were 6th graders. Most students were White (93%; 4% Hispanic or Latinx; 2.1% Mixed, 0.3% Black, 0.2% Asian, 0.3% American Indian or Alaska Native), which was representative of the surrounding school districts demographics. Schools were comparable in their state achievement test scores (62-74% of students meeting state standards) yet ranged in the percentage of low-income students they served (22-80% of students eligible for free or reduced-price lunch). District-level metrics which considered three aspects of socioeconomic status (e.g., whether students are in households

receiving food or cash assistance, are homeless, and/or in foster care) indicated 33% of students in the sample were socioeconomically disadvantaged.

3.3.2 Procedure

Surveys were developed in a consulting capacity in an ongoing research-practice partnership with school-level stakeholders to learn about their students' experiences during remote learning as well as assess their students' academic motivation, engagement, and general well-being. After discussions about their school and their interest in a survey, an initial draft of the survey was sent to the superintendent and school principals, whose feedback and suggestions were considered to improve it. Surveys were administered to students in May 2021 online via an anonymous link provided to them by their teacher in May 2021. Students either completed the survey during class time while learning in-person in their classroom or school computer lab or were provided the survey link to complete at home if learning remotely. On the welcome screen of the survey, students were informed their participation was voluntary, that there were no right or wrong answers, and that their responses would be deidentified and kept confidential from their teachers, principals, parents, and peers. Survey development and data collection were solicited by the school district and a shared data agreement regulated the use of these data for research. These analyses are classified as non-regulated human research according to the Code of Federal Regulations (45 CFR 46.102 (l)) and the University's institutional review board provisions.

3.3.3 Measures

Gender. Students were asked to select their gender from four answer options: 1.) girl (she/her); 2.) boy (he/his); 3.) non-binary (they/them, ze/zie); 4.) prefer not to answer. 32 students self-identified as non-binary, 32 students did not self-identify. Gender contrasts between

boy-girl and boy-nonbinary gender identity were calculated and included in all subsequent analyses. Students who chose not to report their gender identity had their response coded as missing and were not considered among gender comparisons.

Racial/ethnic identity and group membership. Students to the question, "Which of the following options best describe how you identify?" Answer categories included: White; Hispanic or Latinx; Black, Asian; American Indian or Alaska Native; and Mixed. Students responses to racial/ethnic identity categories were calculated at the individual level as racial-ethnic identity contrast of White and aggregated at the class-level as the percentage of White students within each class, in line with previous COVID-19 surveys (EdWeek Research Center, 2020).

Socioeconomic status (SES). District-level data linked with student survey responses included a binary variable which categorized each student as either socioeconomically disadvantaged or not (0 = no, 1 = yes, disadvantaged). This binary categorization of students' socioeconomic status was calculated by the school district as an aggregate of multiple data sources (e.g., whether students are in households receiving food or cash assistance, are homeless, or in foster care). Individual-level SES was aggregated to create a mean score of SES for each class (Level 2 SES mean; see Table 3.1 for ICC). Individual SES was also retained at Level 1 (Chan, 1998).

Remote learning experiences

At the start of the remote learning section of the survey, students were provided the following prompt to help ensure students were thinking of the same experiences as they answered questions regarding the time they had spent remote learning: "Last spring, all school building closed because of COVID-19, and students began learning remotely from home. This year, students have spent different amounts of time learning remotely, and some have moved

back to in-person learning at school. For this next section, we will use the words **'remote learning'** to describe the time you've spent learning from home instead of attending class in person." Students then went on to answer questions regarding their remote learning experiences (described below).

Time spent remote learning (TSRL). Students were asked to report approximately how much of that school year (the 2020-2021 school year) they had spent remote learning via 5 answer options (1 = "*none of this school year"*; 2 = "*less than half of this school year"*; 3 = "*about half of this school year"*; 4 = "*more than half of this school year"*; 5 = "*all of this school year"*)**.** Observed scores on this scale ranged from 0 (0% of school year spent learning remotely) to 5 (100% of school year spent learning remotely). Individual ratings of TSRL were aggregated to create a mean score for each class (Level 2 TSRL mean; see Table 3.1 for ICC). Students' self-reported individual TSRL was retained at Level 1 (Chan, 1998).

Webcam use (CAM) & Daily hours spent in virtual classes (HRS). To assess the daily hours students had spent in virtual classes as well as students' use of their webcam within these classes, a filter question differentiated students who had not spent any hours in virtual class sessions that school year (and thus had no opportunities to use their webcam) from those who simply did not use their webcam in virtual classes. Students were asked to report how often they had attended "a real-time virtual class session with their teacher and their classmates together while remote learning this school year" to which students responded to on a 5-point scale (1 = *never;* 2 = *less than once per week;* 3 = *once a week*; 4 = *multiple times a week;* 5 = *every day or more often*). Examples of videoconferencing platforms were provided in the prompt which the district superintendent confirmed were familiar to their teachers and students (e.g., on Zoom,

Google Meet). If a student had never attended a virtual class that school year, they were forwarded to the next section of the survey and were not asked the following two questions[1].

Daily hours spent in virtual classes (HRS). Students were prompted to think about what a normal school day of remote learning for them had been like this school year. Students then typed in the number of hours during a typical day of remote learning they spent "in live class sessions (ex. on Zoom, Google Meet) like on video calls with your teacher and all of your classmates together" Students were told their answers could range from 0 to 8 hours. Observed scores for this scale ranged from 0 to 60. 47 students reported they spent on average >8 hours in virtual classes during a typical day spent remote learning; these responses were coded as missing as they were outside the possible range (school day did not exceed 8 hours). Individual ratings of HRS were aggregated to create a mean score for each class (Level 2 HRS mean; see Table 3.1 for ICC). Students' individual reporting of HRS were retained at Level 1 (Chan, 1998).

Webcam use (CAM). Students were asked to report on a 5-point scale (1 = *never,* 2 = *sometimes,* 3 = *about half of the time,* 4 = *most of the time,* 5 = *always*) how often they kept their webcam turned on "in live class sessions (ex. on Zoom, Google Meet) with your teacher and all of your classmates together". Observed scores for this scale ranged from 1 to 5. Individual ratings of webcam use were aggregated to create a mean score for each class (Level 2 CAM use mean; see Table 3.1 for ICC). Students' individual webcam use was retained at Level 1 (Chan, 1998).

[1] See further explanation and details regarding these students' exclusion from the final analytic sample on pg. 77-76.

Behavioral and emotional engagement

Students self-reported their levels of behavioral and emotional engagement by responding to 8 items developed by Skinner and colleagues (2009). *Behavioral engagement* was assessed via 4 items (e.g., "I participate in class discussions"; Cronbach's $\alpha = 0.75$) which students responded to on a 5-point scale (1 = *not at all true* to 5 = *very true*), while another 4 items assessed students' *emotional engagement* (e.g., "When I do schoolwork, I feel interested"; Cronbach's $\alpha = 0.87$) which students responded to on a 5-point scale (1 = *not at all true* to 5 = *very true*). To create classroom-level measures of behavioral and emotional engagement, students' individual perceptions were aggregated to create L2 mean scores of behavioral and emotional engagement for each class (see Table 3.1 for ICC), while their individual perceptions were retained at Level 1 (Chan, 1998).

Academic Achievement

Students' achievement on the MSTEP English and mathematics subtests was obtained from school-provided records. Observed maximum scores on the mathematics and English subtests among the students in the sample were 1,703 (SD = 85.134) in mathematics and 1,683 (SD = 89.130) in English. A test score of 1,300-1,320 (3^{rd} grade) to 1,600-1,613 (6^{th} grade) in mathematics and 1,300-1,316 (3^{rd} grade) to 1,600-1,623 (6^{th} grade) in English are considered the cut-offs for proficiency in each subject. Student's scores on the mathematics and English subtests were summed to form a single index of achievement (observed range = 2,484 to 3,386). The mean score was 2,801.10 (SD = 173.46). As cutoffs for proficiency in either subject were higher or lower depending on grade-level, summed scores for achievement were standardized within grade-level.

3.3.4 Final analytic sample and handling of missing data

The survey was completed by 1,575 students. Necessary exclusions from the sample included students who had learned in person for the entirety of the 2020-2021 academic year (109 students, or 7.0% of the sample) as well as students who had not attended a virtual class session during the 2020-2021 school year (40 students, 2.5% of the sample). These students were excluded as neither had the opportunity to use their webcam that school year; their exclusion ensured the lowest value of the webcam use measure denoted students who never used their webcam during virtual class sessions and did not include students who had never used their webcam because they had not had the opportunity.

Among the remaining 1,426 students, 378 students did not have corresponding achievement data (i.e., Mathematics and English subset scores from that year's MSTEP state achievement test). During the 2020-2021 school year, U.S. schools were allowed to waive some federal high-stakes school accountability requirements, including the requirement to assess students' achievement with a participation rate of at least 95 percent. Most U.S. states (including Michigan, where students were surveyed) provided students and their parents the option to opt-out of state testing. Approximately 70% of eligible Michigan students participated in Spring testing for ELA and Mathematics in 2020-2021 school year (Michigan Office of Educational Assessment and Accountability, 2021). Among the sample, 74% of students participated, thus the sample had a slightly lower opt-out rate than was typical in the state[2].

Independent samples t-tests were conducted to compare students with achievement data to those who had opted out of state testing (i.e., did not have achievement data). Students who opted out tended to be older ($M_{difference}$ = .653, 95% CI [.547, .758], t = 12.142, p <.001), had

[2] These rates are significantly lower than participation rates in previous years of the MSTEP assessment, making any comparison to previous years' data problematic.

spent more of that school year learning remotely ($M_{difference}$ = .995, 95% CI [.898, 1.091], t = 20.304, p <.001), and reported lower levels of behavioral ($M_{difference}$ = -.132, 95% CI [-.214, -.050], t = -3.173, p =.002), and emotional engagement ($M_{difference}$ = -.236, 95% CI [-.350, -.112], t = -3.622, p <.001), on average. However, there was not a significant difference in self-reported webcam use between students with and without achievement data, $M_{difference}$ = -.067, 95% CI [-.229, .094], t = -.819, p = .413. Further, no differences were found between these students by gender or ethnic-racial identity.

Characteristics of the final analytic sample are provided in Table 3.2. Percentage of missing values across study variables varied between 0 and 7.3%. Multilevel models were estimated using full maximum likelihood (FML) estimation procedures (Snijders & Bosker, 2012).

3.3.5 Analysis Plan

To assess the study aims as well as to account for that the data are not independent (students in the sample were nested within 62 elementary school classrooms), hierarchical linear modeling (HLM) was utilized. HLM can assess cross-level data relationships and the effects of between- and within-group variance of a predictor on an outcome of interest (Raudenbush & Bryk, 2002), thus enabling this study to differentiate variation between student and classroom-level in webcam use to explain variation in individual achievement after accounting for variation in students' and classrooms' behavioral and emotional engagement.

First, to identify significant associations among the study variables before inclusion in the hierarchical regression model, zero-order correlations between all study variables were performed (see Table 3.3). Partial correlations were then conducted (see Table 3.4) to identify characteristics of students and classrooms that predicted students' frequency of webcam use in

virtual classes. To test the main hypotheses, I conducted two-level multilevel models using the package *nlme* (Pinheiro et al. 2014) in RStudio. Student-level (Level 1) variables were group mean centered (to reflect each student's individual rating respective to other students in their class), while class-level (Level 2) variables were grand mean centered (to reflect each individual class's rating respective to other classes in the sample). In essence, group mean centering L1 predictors and grand mean centering L2 predictors "reintroduces the mean", allowing for the examination of separate within-group and between-group effects onto the same outcome (i.e., achievement). I included three covariates at both Level 1 and Level 2 identified during my review of the literature as likely influential to the relationship between students' webcam use and their objective achievement: SES, TSRL, and HRS. I further control for (at both Level 1 and at Level 2) behavioral and emotional engagement, as an aim of this study was to differentiate student- and classroom-level webcam use from other forms of student engagement to identify whether webcam use has a unique effect on achievement.

To assess whether there is appropriate variance in achievement between classrooms to investigate the study aims, I first conducted an intercept-only model (Model 0). Then, Models 1-3 examined individual-level associations with the dependent variable, beginning with student characteristics (i.e., SES, TSRL, and HRS) in Model 1[3], followed by individual webcam use in Model 2, and individual behavioral and emotional engagement in Model 3. Model 4-6 examined class-level associations with the dependent variable, first by adding the three L2 covariates (SES

[3] Individual- and class-level race/ethnicity contrasts were not significantly correlated with individual- or class-level achievement or individual- or class-level webcam use. Gender contrast for boy-nonbinary did not correlate with achievement yet was negatively correlated with webcam use (r = -.07, p<.001)(see Table 3.4); gender contrast for boy-girl was negatively correlated with achievement (r = -.09, p<.001) but was not correlated with webcam use (see Table 3.3). Adding race/ethnicity and gender contrasts into all HLM models did not alter the significance of the findings nor were they significant on their own. Thus, we exclude them from the HLM analyses to increase interpretability and simplify the models.

mean, TSRL mean, and HRS mean) in Model 4, then in Model 5 adding L2 webcam use (Webcam use mean), followed by L2 behavioral and emotional engagement (BENG mean and EENG mean) in Model 6. Model 7 considered a cross-level interaction between individual- and class-level webcam use, aligning with my hypothesis that class-level webcam use moderates the relationship between individual webcam use and achievement.

The general HLM model is as follows:

Level 1

$$Achievement_{ij} = \beta_{0j} + \beta_{1j}(SES_{ij}) + \beta_{2j}(TSRL_{ij}) + \beta_{3j}(HRS_{ij}) + \beta_{4j}(CAM_{ij}) + \beta_{5j}(BENG_{ij}) + \beta_{6j}(EENG_{ij}) + r_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(SES_j) + \gamma_{02}(TSRL_j) + \gamma_{03}(HRS_j) + \gamma_{04}(CAM_j) + \gamma_{05}(BENG_j) + \gamma_{06}(EENG_j) + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40} + \gamma_{41}CAM_j + \mu_{4j}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

3.4 Results

3.4.1 ICCs of L1 variables

Table 3.1 displays the between class variation for all L1 predictors to support their aggregation at Level 2. Time spent remote learning exhibited the largest variability between classrooms (47%) followed by daily hours spent in virtual classes (40%). Throughout the 2020-2021 school year, COVID-19 social distancing protocols were incredibly variable between

schools and classrooms as each shifted between fully in-person, hybrid, and remote learning for students depending on the pandemic conditions of the surrounding area as well as risk of exposure within the school and/or classroom in which students resided. Classrooms also varied considerably in the average SES among their students (24%). Webcam use, behavioral and emotional engagement each varied appreciably between classrooms (11%, 10%, 7%, respectively). Achievement demonstrated 7% variance at the classroom-level, which is consistent with intraclass correlations for achievement typically found among this age group (Hedberg & Hedges, 2014).

3.4.2 Zero-order correlations between all study variables

Correlations between all study variables are presented in Table 3.3. Student-level webcam use exhibited a moderate correlation with class-level webcam use (r = .41, p<.001). Student-level behavioral and emotional engagement exhibited a moderate correlation with one another (r = .50, p<.001) and were each weakly correlated with student-level webcam use (both r = .19, p<.001). Class-level behavioral and emotional engagement were strong-to-moderately correlated (r = .61, p<.001) and each exhibited a weak-to-moderate correlation with class-level webcam use (r = .12, p<.001, and r = .28, p<.001, respectively). Moderate correlations between the measures of engagement (behavioral and emotional) yet their mutual weak correlations with webcam use suggests students' webcam use is a separable construct from their engagement.

3.4.3 Correlates of elementary school students' webcam use

The first aim of this study was to identify student and classroom characteristics associated with elementary school students' frequency of using their webcam in virtual classes. Partial correlations between student- and class-level webcam use and all study variables are

provided in Table 3.4. When class-level webcam use (L2 CAM) was held constant, student-level webcam use (L1 CAM) was correlated with (in order of magnitude): students' individual behavioral engagement (r=.17, p<.01), individual achievement (r=.12, p<.01), having a non-binary gender identity (r=-.11, p<.01), individual emotional engagement (r=.10, p<.05) and individual SES (r=-.10, p<.05). Once student-level webcam use (L1 CAM) was held constant, class-level webcam use (L2 CAM) was correlated with (in order of magnitude): classroom mean achievement (r=.34, p<.01), classroom mean emotional engagement (r=-.21, p<.01), classroom mean hours spent in virtual classes (r=-.18, p<.01), individual achievement (r=.12, p<.01), and classroom percentage of girls (r=-.10, p<.05). None of the class-level variables were correlated with individual-level webcam use once class-level webcam use was held constant; however, individual-level achievement exhibited a significant correlation with class-level webcam use even after individual webcam use was held constant.

3.4.4 Null model

Results of the intercept-only model indicated that, within the total variance of 1.007 (0.937 + 0.067 = 1.007) in the outcome variable (achievement), the estimate for within-group (Level 1) variance (i.e., variance of r_{ij}) was 0.937, whereas the between-class variance (variance of μ_{0j}) was 0.067 (see Table 3.5). In other words, differences between students accounted for 94% (0.937/1.007) of the total variance in students' academic achievement, whereas 7% (0.067/1.007 = 7%) of the total variance was at the classroom-level. This is consistent with intraclass correlations typically found for achievement among this age group (7%; Hedberg & Hedges, 2014).

3.4.5 Level 1 models

Model 1 added fixed effects of the three individual-level covariates (i.e., SES, TSRL, and HRS). AIC statistics indicated Model 1 was much better fit than the null model (i.e., AIC decreased by 999.5). Greater amount of time spent remote learning (TSRL) compared to classmates as well as socioeconomic disadvantage (SES) were each associated with lower-than-average achievement scores for grade-level. More daily hours spent in virtual classes (HRS) compared to classmates was not associated with achievement score. Adding these three covariates explained 6% of the 94% total variance at Level 1 and 1% of the 7% total variance at Level 2 in students' achievement (MSTEP scores).

Model 2 added individual webcam use as a fixed as well as a random effect. AIC statistics indicated Model 2 was better fit than Model 1 (i.e., AIC decreased by 293). Results for Model 2 indicated more frequent webcam use compared to classmates was predictive of higher achievement (students' SES, TSRL, and HRS held constant). Adding individual-level webcam use to the model explained 4% of the remaining 87% total variance at Level 1 but did not explain additional variance at Level 2 in students' achievement (MSTEP scores). Between classroom variation in webcam use (webcam use slope) explained 2% of the total variance in achievement.

Model 3 added fixed effects for individual-level behavioral and emotional engagement. AIC statistics indicated Model 3 was better fit than Model 2 (i.e., AIC decreased by 28.4). Results of Model 3 indicated higher levels of behavioral engagement as well as higher levels of emotional engagement compared to classmates were each associated with higher achievement. Upon adding student-level behavioral and emotional engagement to the model, the previously identified significant and positive association between individual webcam use and achievement became non-significant. This indicated the fixed effect of individual webcam use on achievement was explained by individual behavioral and emotional engagement. Adding fixed effects of

individual behavioral and emotional engagement to the model explained an additional 4% of the remaining 83% total Level 1 variance in achievement.

3.4.6 Level 2 models

Model 4 added three class-level covariates: % disadvantaged (SES mean), class mean of time spent remote learning (TSRL mean) and class mean of daily hours spent in virtual classes (HRS mean). AIC statistics indicated Model 4 was better fit than Model 3 (i.e., AIC decreased by 10.1). Analyzing the data from Model 4, the model predicts the highest achievement (MSTEP scores) for students who resided in classrooms with a lower proportion of socioeconomically disadvantaged students. Differences between classes in daily hours spent in virtual classes (HRS mean) as well as duration of the 2020-2021 school year spent learning remotely (TSRL mean) were each not predictive of differences in individual achievement among students. Adding these class-level covariates explained an additional 1% of the remaining 79% Level 1 variance and 2% of the remaining 6% Level 2 variance in achievement.

Model 5 added class-level webcam use as a fixed effect. AIC statistics indicated Model 5 was better fit to the data than Model 4 (i.e., AIC decreased by 5.4). Analyzing the data from Model 5, the model predicts the highest achievement (MSTEP scores) for students who resided in classrooms with higher mean frequencies of webcam use. Class-level webcam use explained 3% of the remaining 4% Level 2 variance in student achievement (MSTEP scores).

In Model 6, class-level behavioral and emotional engagement were added as fixed effects onto the estimation of individual achievement. Model fit statistics indicated Model 6 fit was somewhat poorer compared to Model 5 (AIC increased by 3). The results of this model indicated class-level behavioral or emotional engagement each not associated with individual achievement,

further, their inclusion did not alter the significance of the association between class-level webcam use and achievement.

3.4.7 Cross-level interaction

Model 7 added a cross-level interaction term between Level 1 and Level 2 webcam use. Model fit statistics indicated Model 7 was better fit to the data than Model 6 (AIC decreased by 2.6) yet fit was not significantly improved from Model 5 (AIC increased by 0.6). The significance of the cross-level interaction term in Model 7 indicates class-level webcam use moderated the association between individual webcam use and individual achievement, which is further supported by an insignificant fixed effect of student-level webcam use in Model 2 and a significant fixed effect of class-level webcam use in Model 5.

3.5 Discussion

Accelerated by the COVID-19 pandemic, virtual class sessions via videoconference have become a common tool utilized by teachers and students in K-12 education when they cannot meet in person. This study investigated elementary school students' webcam use during virtual classes in comparison to their educational outcomes, specifically their perceived engagement and end-of-year achievement.

The first research aim of this study was to identify individual and classroom characteristics that were associated with children's more frequent webcam (non)use while attending virtual classes. Partial correlation analyses indicated children who used their webcam less frequently than peers were more likely to be socioeconomically disadvantaged and to report a non-binary gender identity. Conversely, children who used their webcam more frequently than peers tended to be high achieving, as well as report higher levels of behavioral and emotional engagement.

Qualitative studies have noted a common explanation students provide for why they do not use their webcam in virtual classes is because they are uncomfortable letting others see inside of their homes (Gherheș et al., 2020). This finding supports this depiction with evidence that elementary school students' individual webcam use in virtual classes corresponded to their socioeconomic advantage or disadvantage at home, as defined through a binary variable which aggregated household qualification for meal assistance, homelessness, and/or foster care status. Partial correlations also provided an unanticipated finding unique to this study; that children who identified as non-binary tended to report using their webcams less frequently during virtual classes than binary students. Recent studies examining students' reasoning for keeping their webcam on or off during virtual classes have not yet considered the influence of students' gender identity on this use, although studies have identified gender as playing a significant role in the formation of both social and physical presence in online courses (e.g., Lombard & Ditton, 1997). This finding suggests greater attention be paid to non-binary students' device use, learning preferences, and experiences in online education and learning remotely.

Partial correlations also indicated classroom experiences and characteristics were associated with differences in average webcam use between classrooms. Specifically, elementary classrooms that had spent a greater number of hours each day in virtual classes tended to have established norms where students used their webcams less frequently. Classrooms with larger proportions of girls exhibited less frequent webcam use. Conversely, high achieving classrooms as well as classrooms characterized by high levels of emotional engagement were each more likely to have also established norms of frequent webcam use among students.

At each level, socioeconomic disadvantage, gender, emotional engagement, and achievement played a role in webcam use; both in how often students used their webcam as well as the norms

of webcam use that were established within elementary school classrooms. Altogether, these findings bolster recent evidence that students' webcam use is influenced by both individual- and group-level processes (Händel et al., 2022). Händel and colleagues (2022) found that, among undergraduates, when more of their peers used their webcam, students tended to keep their webcam on more often as well as participate more frequently via chat in virtual classes. This study corroborates this finding among elementary school students, providing evidence of a general tendency of students to attune to the webcam use of peers in a virtual classroom regardless of age or stage of maturity. As such, more research on social forces which promote and diminish children's desire to use their webcam in virtual classes, and how this affects students' academic outcomes in online courses is warranted.

In this study, students' webcam use was related yet distinct from other forms of student engagement in learning. Prior work describes student webcam use as a form of engagement in virtual classes (*i.e., visual engagement;* Händel et al., 2022) or at least as supportive of students' engagement in learning more so than students keeping their webcams off (Nguyen et al., 2021). Yet no study to date had yet compared students' frequency with which they used their webcam in virtual classes to well-established forms of engagement (behavioral and emotional engagement). Utilizing two measures of engagement utilized with K-12 student samples(Fredricks et al, 2004), the findings of this study identify the frequency with which elementary school students used their webcam in virtual classes was only weakly correlated with their perceived level of behavioral and emotional engagement in learning. Further, elementary school classrooms with established norms of more frequent webcam use were only weakly correlated with also having higher average levels of behavioral and emotional engagement among students. This suggests K-12

students' (specifically elementary school students') webcam use is likely not a good representation of how engaged they are in learning while attending a virtual class.

The results of the multi-level models revealed residing in elementary school classrooms characterized by more frequent webcam use was associated with students' higher individual academic achievement (higher than average for grade-level MSTEP achievement score). This was true even after accounting for the unique effects of individual and classroom SES, behavioral engagement, and emotional engagement on academic achievement. Previous studies find students' level of behavioral and emotional engagement in learning is consistently associated with their academic achievement (Engels et al., 2021; Soffer & Cohen, 2019). In this study, individual webcam use was not uniquely associated with individual achievement over and above individual behavioral and emotional engagement, however, average classroom webcam use was positively associated with individual achievement. This provides further evidence that webcam use differs from traditional forms of engagement in its relationship with achievement, as average classroom webcam use – but not individual webcam use – is predictive of higher achievement.

The significance of the cross-level interaction term indicated a context effect for webcam use; average classroom webcam use moderated the relationship between individual webcam use and end-of-year achievement. In other words, in elementary school classrooms where students typically kept their webcams on, the frequency with which individual students used their webcam was more important for their individual achievement. Conversely, in classrooms that allowed greater exemptions for opting out of webcam use based on student preference and/or where webcam use was generally not the norm among students, individual webcam use was less important for individual achievement. Though the cross-level interaction was significant, the

model which included the cross-level interaction did not exhibit a better fit than the previous model that only considered classroom-level webcam use. Thus, the cross-level interaction did not explain more of the variance in students' academic achievement than did simply assessing the average webcam use of their class.

It is important to note that the findings of this study do not and cannot differentiate causality in the association between individual- and classroom-level webcam use and academic achievement. It may be that teachers who required webcam use in their classrooms or were simply more successful at encouraging students to use their webcams already contained a greater proportion of high-achieving students. Teachers in classrooms with a higher proportion of high-achieving students may have had an easier time convincing students to use their webcam, as high-achieving students are generally more prosocial, helpful to their peers, and engaged in learning (Ryan et al., 2019). Further, classrooms with a higher proportion of high achievers may reside in school communities with strict regulations already in place regarding students' participation in learning and for their academic success (Cornell et al., 2016). Thus, it may be easier for school and classroom contexts that are already high achieving to require students' webcam use without students' or parents' resistance. This study identifies an association between classroom webcam use and individual academic achievement, but further research is needed in order to determine the causality in this association as well as explicate the unique contributions of school-, classroom-, and individual-level influences on students' webcam use and students' achievement within this association.

3.6 Strengths and Limitations

While a strength of this study is that it utilizes an objective measure of academic achievement (MSTEP scores), all other study variables were self-report. As such, the findings of

this study are more prone to social desirability bias. While children and adolescents are fully capable of reporting their feelings and school experiences (Eccles et al., 1993), parallel reports (from teachers and/or parents) may have provided a more balanced view of students' learning behaviors and learning experiences during this time. Yet although reporting from teachers and parents often parallel students, recent studies conducted during the COVID-19 pandemic find student and teacher reports measurably differed regarding what student's remote learning entailed (e.g., Fabriz et al., 2021). Thus, a multi-informant approach may not have provided more accurate depictions of students' remote learning experiences (i.e., how engaged students were, either via webcam, behaviorally, or emotionally) during this time so much as reporting from the students themselves.

Further, this study's measure of webcam use was self-report, and did not measure the actual time (in hours or proportional time) that students with webcam on during virtual classes. As the students in the sample were relatively young (3^{rd}-6^{th} grade) and had spent different amounts of time that school year learning remotely, asking them to report the number of hours they typically spent each day *with their webcam on* in virtual classes was deemed by the research team to be too difficult for younger children to approximate. Covariates were included which should account for differences in the time students had spent learning remotely (TSRL) as well as daily hours they spent in virtual classes (HRS), both at the individual level and between classrooms. More research may be needed to determine the value of systems data of students' webcam use respective to self-reported webcam use, engagement, and objective measures of academic achievement.

Another strength of this study is that it was able to assess individual webcam use respective to the webcam use of the students in a classroom and whether each were predictive of

student achievement. However, the sample did not contain enough schools to account for school-level effects in the hierarchical model. As such, it could be school-level norms and policies regarding webcam use, or school-level SES, TSRL, and HRS, are more so influential for student achievement than these are at the class-level. Future research could replicate these findings with more precise nested models that consider students, within classrooms, within schools.

3.7 Conclusion

This study examined multi-level associations between elementary school students' webcam use in virtual classes, their engagement, and achievement relative to other students. Multi-level models indicated SES played a consistent role in students' webcam use, both in how often students used their webcam relative to peers as well as the norms of webcam use that were established amongst elementary school classrooms. Correlations identified children's webcam use was only weakly related to their perceived behavioral and emotional engagement in virtual classes. MLM analyses revealed children's more frequent webcam use was not predictive of achievement over and above their behavioral and emotional engagement, however classrooms that had established norms of more frequent webcam use were positively predictive of individual achievement (class-level behavioral and emotional engagement were not). Finally, a context effect was identified such that class-level webcam use moderated the association between individual-level webcam use and achievement. Altogether, the present findings suggest students' webcam use is a related yet separable construct from their behavioral and emotional engagement, which exhibits a different pattern of association with achievement (i.e., operating at the classroom- rather than the individual-level).

Figure 1. Summary of Study 2 research hypotheses

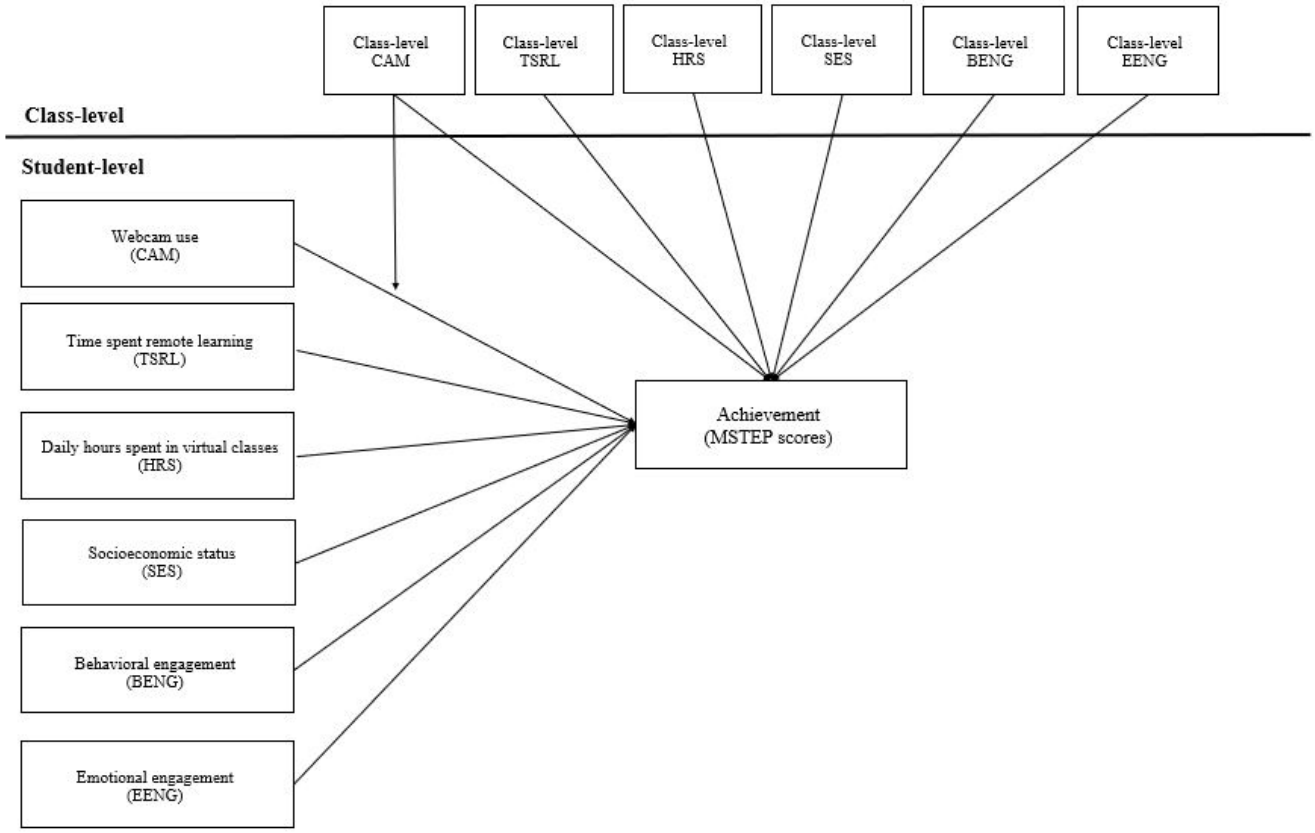

Table 3.1. *Intraclass correlation coefficients for all L1 variables*

Measures	Intraclass Correlation Coefficient
Time spent remote learning (TSRL)	.47
Daily hours spent in virtual classes (HRS)	.40
Socioeconomic status (SES)	.24
Webcam use (CAM)	.11
Emotional engagement (EENG)	.10
Achievement	.07
Behavioral engagement (BENG)	.07

Table 3.2. *Study 2 sample characteristics* (N = 1426)

Variable	Percentage of students
Gender	
Male	48.7
Female	46.8
Non-binary	2.3
Non-specified	2.3
Grade-level	
3rd	31.4
4th	37.5
5th	28.3
6th	2.8
Socioeconomic status	
Yes, disadvantaged	33.8
No	66.2
Racial/ethnic identity	
White	93.3
Black or Afican American	0.4
Hispanic or Latinx	3.9
American Indian or Alaska Native	0.1
Asian	0.2
Mixed	2.1
Special education status	
Yes	9.9
No	90.1

Table 3.3. *Correlations between all Study 2 variables*

	Level 1									Level 2										
Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
Level 1																					
1. Grade	1.0																				
2. Boy - Girl	-.07*	1.0																			
3. Boy - Nonbinary	.06*	-.20**	1.0																		
4. Racial/ethnicity (White)	-.02	-.03	.01	1.0																	
5. SES[1]	-.068*	.01	-.02	-.10**	1.0																
6. Time spent remote learning	.21**	.03	.00	.01	.15**	1.0															
7. Daily hours spent in virtual classes	.14**	-.03	.05	-.01	.02	.26**	1.0														
8. Webcam use	-.04	.02	-.07*	.04	-.09**	-.01	.02	1.0													
9. Behavioral engagement	-.13**	.12**	-.14**	.05	-.17**	-.04	.00	.19**	1.0												
10. Emotional engagement	-.14**	.08**	-.14**	.05	-.08**	-.02	.00	.19**	.50**	1.0											
11. Achievement	.00	-.09**	.03	.03	-.32**	-.19**	-.07	.13**	.25**	.15**	1.0										
Level 2																					
12. % Girl	-.29**	.23**	-.06*	-.05	.08*	-.03	.01	-.02	.04	.03	-.03	1.0									
13. % Non-binary	.23**	-.05	.28**	.04	-.01	.07**	-.02	.01	-.08**	-.11**	.05	-.22**	1.0								
14. % White	.01	-.03	.01	.30**	-.04	-.04	.02	.07*	.05	.01	.04	-.14**	.03	1.0							
15. SES mean	.09**	.02	.00	-.03	.37**	.22**	.08*	-.10**	-.12**	-.07*	-.14**	.08**	-.02	-.26**	1.0						
16. TSRL mean	.32**	-.01	.03	.00	.16**	.69**	.32**	-.02	-.06*	-.04	-.14**	-.04	.10**	-.05	.32**	1.0					
17. HRS mean	.21**	-.02	.03	-.03	-.03	.22**	.63**	-.04	-.03	-.01	.02	-.11**	.10**	-.17**	.02	.34**	1.0				
18. CAM mean	-.06*	-.02	.02	.02	-.05	-.050	-.02	.41**	.03	.10**	.12**	-.08**	.07**	.18**	-.26**	-.07**	-.10**	1.0			
19. BENG mean	-.37**	.03	-.07**	.04	-.10**	-.11**	-.05	.05	.36**	.24**	.03	.12**	-.25**	.11**	-.34**	-.16**	-.09**	.12**	1.0		
20. EENG mean	-.38**	.02	-.08**	-.02	-.04	-.06*	-.01	.12**	.22**	.39**	.04	.07*	-.28**	.04	-.18**	-.08**	.01	.28**	.61**	1.0	
21. Achievement mean	-.14**	.03	.00	.03	-.15**	-.29**	-.24**	.08**	.02	.01	.36**	.16**	.06*	.02	-.22**	-.43**	-.13**	.25**	.04	.03	1.0

[1]SES was coded as 0 for not disadvantaged, 1 for disadvantaged.

[2]SES mean reflects increasing percent of students in class that were disadvantaged.

Note: *p <.05; **p <.01. SES, TSRL, HRS, CAM, BENG, and EENG are used to abbreviate socioeconomic status, time spent remote learning, daily hours spent in virtual class sessions, webcam use, behavioral engagement, and emotional engagement, respectively.

Table 3.4. *Partial correlations between all L1 & L2 variables and L1 & L2 webcam use*

	Partial correlations	
Measure	L1 CAM *(controlling for L2 CAM)*	L2 CAM *(controlling for L1 CAM)*
Level 1		
Grade	-.02	.01
Boy - girl	.05	-.05
Boy - nonbinary	-.11**	.06
Racial/ethnic identity (White)	.03	-.03
SES[1]	-.10*	.00
Time spent remote learning (TSRL)	-.04	-.03
Daily hours spent in virtual classes	-.01	-.09
Behavioral engagement (BENG)	.17**	-.02
Emotional engagement (EENG)	.10*	.06
Achievement	.12**	.12**
Level 2		
% Girl	.02	-.10*
% Non-binary	-.01	.08
% White	.02	-.01
SES mean[2]	.02	.02
TSRL mean	.01	.03
HRS mean	.02	-.18**
BENG mean	.01	.05
EENG mean	.00	.21**
Achievement mean	-.01	.34**

[1]SES was coded as 0 for not disadvantaged,

[2]SES mean reflects increasing percent of

Note: *p <.05, **p<.01. SES, TSRL, HRS, CAM, BENG, and EENG are used to abbreviate socioeconomic status, time spent remote learning, daily hours spent in virtual class sessions, webcam use, behavioral engagement, and emotional engagement respectively.

Table 3.5. *Multilevel models predicting L1 achievement (MSTEP scores) from individual- and class-level webcam use, behavioral and emotional engagement*

	Null	Student-level			Class-level			
	Model 0 β (SE)	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)	Model 5 β (SE)	Model 6 β (SE)	Model 7 β (SE)
Fixed Effects								
Intercept	-0.03 (0.05)	0.06 (0.05)	0.09 (0.05)	0.08 (0.05)	0.01 (0.05)	0.03 (0.05)	0.03 (0.05)	0.02 (0.05)
Student Characteristics								
SES		-.648***	-.622***	-.556***	-.564***	-.561***	-.561***	-.566***
TSRL		-.182***	-.166**	-.164**	-.157**	-.148**	-.146**	-.144**
HRS		-.031	-.029	-.019	-.020	-.020	-.022	-.019
Student-level Webcam Use								
CAM			.074*	.046	.049	.044	.044	.053
Level 1 Control								
BENG				.231***	.240***	.240***	.244***	.234***
EENG				.096*	.093*	.095*	.093*	.096*
Class-level Covariates								
SES mean					-.699*	-.657**	-.797**	-.788**
TSRL mean					-.157	-.141	-.126	-.108
HRS mean					-.069	-.055	-.007	-.072
Class-level Webcam Use								
CAM mean						.266**	.248**	.294**
Level 2 Control								
BENG mean							-.279	-.255
EENG mean							.113	.108
Interactions								
CAM x CAM use mean								.200*
Variance Components (random effects)								
Student-level variance	.94	.87	.83	.79	.78	.78	.78	.78
Class-level variance	.07	.05	.06	.06	.04	.01	.01	.01
Webcam use slope			.02	.02	.03	.03	.03	.02
Model Fit								
-2Log likelihood	-1470.9	-968.2	-818.7	-802.5	-794.5	-790.7	-790.3	-788.0
AIC	2947.9	1948.4	1655.4	1627.0	1616.9	1611.5	1614.5	1612.1

[1]SES was coded as 0 for not disadvantaged, 1 for disadvantaged.

[2]SES mean reflects increasing percent of students in class that were disadvantaged.

Note: *p <.05; **p <.01, ***p<.001. SES, TSRL, HRS, CAM, BENG, and EENG are used to abbreviate socioeconomic status, time spent remote learning, daily hours spent in virtual class sessions, webcam use, behavioral engagement, and emotional engagement respectively.

Chapter 4 – Conclusion

Emergency remote learning during the COVID-19 pandemic marked a significant milestone in education – for the first time, the predominant format of learning in K-12 education was not classroom delivery, but students learning remotely from home and for the most part, online. Emergency remote learning during the COVID-19 pandemic was an attempt by nations around the world to mitigate the anticipated negative effect of prolonged school closures and social distancing on the current and future learning outcomes of today's school-age youth.

K-12 educators, with little time to plan and little guidance as to how to shift their in-person instruction online, experimented with a variety of online and remote learning modalities and instructional deliveries (for some, up to a year or more) in order to meet this goal. Near universal remote learning across elementary, middle, and high schools throughout the pandemic now grants education researchers a unique opportunity to gain insights into supports for children's' and adolescents' engagement when learning online and remotely which are more generalizable to this population than previously possible. Forged in the midst of COVID, this dissertation sought to address two overarching questions to take hold of this opportunity. First, what was children and adolescents' online and remote learning like at the start of the pandemic and throughout the year that followed (the 2020-2021 school year), and 2.) What online and remote instructional and pedagogical strategies were associated with K-12 students' higher levels of engagement in learning and emotional well-being throughout this time? Collectively, the findings of the two studies of this dissertation reveal a variety of instructional and pedagogical

strategies, social supports, and individual characteristics and perceptions that were supportive of children and adolescents' learning while learning from home. Each study yields important theoretical and practical implications for future study, whether learning occurs in person, at home, or online.

Broadly, this dissertation contributes to historical knowledge of K-12 students' educational experiences throughout the COVID-19 pandemic. Across studies, K-12 students' learning experiences were described at two time points: immediately after shifting from in-learning person to learning remotely (2 months after school closures), and one year later, after students had spent varying amounts of the 2020-2021 school year learning remotely and in-person. Study 1 provided a more holistic understanding of what a typical day of remote learning was like in the immediate aftermath of school closures at the onset of the pandemic for the high school students I surveyed. On average, adolescents in the sample spent 2/3rd of their day sleeping or on forms of entertainment (e.g., socializing with friends, playing games), 1/3rd of their day on housework (such as chores and taking care of siblings), and 1/3rd of their day participating in online/remote learning activities. Study 1 further identified 5 patterns among the third of their day adolescents spent participating in online and remote learning activities: *teacher transitional support, zoom-heavy, heavy workload, chaotic, and heavy social load*. These descriptions together suggest two months in to emergency remote learning at the start of the pandemic was likely an amorphous time in adolescents' lives, characterized by less time spent on school activities, variable learning experiences, and more time spent entertaining oneself alone. One year later, Study 2 identified elementary school classrooms differed widely in the time they spent learning remotely the 2020-2021 school year, as well as the time they dedicated to synchronous virtual classes.

Both Study 1 and 2 together identified evidence of students' more negative academic perceptions after an abrupt transition to learning remotely as well as after extended remote learning. Adolescents in Study 1 reported a significant decline in their engagement, positive affect, and opportunities for peer interaction after they transitioning from learning in person to learning remotely. Study 2 identified the greater amount of time children had spent learning from home rather than in person was predictive of their poorer end-of-year achievement, even after controlling for differences in individual and classroom SES, hours spent in virtual classes, and behavioral and emotional engagement. Further, classrooms that spent a greater proportion of the 2020-2021 school year learning remotely typically had lower than average achievement scores among individual students.

Previous research on remote learning during the COVID-19 pandemic has demonstrated systemic inequities in students' financial and social resources and supports for their learning transcend in learning environments (Rashid & Asghar, 2016; Felisoni & Godoi, 2018; Elliot-Dorans, 2018; Donovan et al., 2010). Whether student learning occurred at home or online, both studies of this dissertation identified students' socioeconomic status and home lives played an outsized role in their ability to engage and succeed academically at the same level as their peers. In Study 1, adolescents who reported having poorer social support at home during emergency remote learning and more frequent home distractions tended to report lower levels of engagement compared to their peers 2 months post-transition. Study 2 identified household socioeconomic disadvantage was tied to children's less frequent use of their webcam during virtual classes, lower levels of behavioral and emotional engagement, and lower than average for grade end-of-year achievement. Other findings of this dissertation unfortunately suggest these experiences likely continued for socioeconomically disadvantaged youth the following school

year, as socioeconomic disadvantage was also associated with students spending a greater proportion of the 2020-2021 school year learning remotely (per Study 2).

Previously unidentified online learning disparities also emerged from this dissertation, specifically in relation to the influence of youth's gender identity on their learning throughout the pandemic. In Study 2, elementary school classrooms with a greater proportion of girls were characterized by norms of less frequent camera use. As Study 2 additionally identifies classroom-level webcam use as associated with individual end-of-year achievement (i.e., norms of less frequent webcam use predictive of lower achievement scores), this disparity may be of interest to future study and confirmation among other student populations.

Previously unidentified disparities in online learning also emerged from this dissertation, specifically there was strong evidence of a connection between classroom gender proportionality, individual gender identity, and the frequency with which students kept their webcam on in virtual classes. In Study 2, elementary school classrooms with a greater proportion of girls were more likely to have established norms of less frequent webcam use while learning online. As Study 2 additionally identified average classroom webcam use (and not individual webcam use) was associated with individual achievement, this disparity is of interest to future study and needs confirmation among other student populations. Further, students who identified as non-binary (i.e., whose gender identity did not conform to either male or female) tended to report using their webcams less frequently in virtual classes on average than students who were binary (i.e., girl or boy). Past and recent investigations of students' gender relative to their use of learning technologies, specifically, their willingness to keep their webcam on in virtual classes (e.g., Colley, 2003; EdWeek Research Center, 2020) have not yet considered the broader spectrum of gender to which youth ascribe. One recent study of COVID-19 emergency remote learning did

consider non-binary students alongside boys and girls' remote learning experiences; they found non-binary students reported having fewer collaborations and discussions with peers and reported greater worry and lack of support in their remote learning compared to binary students (Oinas et al., 2022). These findings suggest there is need for future online and distance learning studies to pay greater attention to children and adolescents' gender identity, and to measure this construct more broadly, in order to fully understand students' use of learning technologies, their experiences, respective to their learning outcomes when learning online and remotely.

The second aim of this dissertation was to identify instructional and pedagogical strategies supportive of K-12 students' engagement in learning while learning online and remotely. Indeed, Study 1 and 2 identified numerous strategies. Results from Study 1 specifically point to the importance of high-quality teacher-student relationships and interactions for adolescents' engagement as well as positive affect after shifting from learning in-person to remotely. This aligns with studies which find high quality teacher-student relationships are predictive of adolescents' perceived fit within new learning contexts, which in turn, predict their engagement and later achievement within them (Zimmer-Gembeck et al., 2006). Likewise, frequency of opportunities for peer interaction appeared important for adolescents' higher level of engagement while learning remotely, i.e., a consistent finding among peer relations studies (for review, see Ryan et al., 2019). Study 2 identified peer interaction via webcam may support children's engagement as well, as children's ability to see more of their peers faces and facial expressions within a virtual classroom was predictive of the higher average emotional engagement of the class as a whole. These findings underline what we know to be fundamental for learning from nearly 100 years of educational research: that social interaction is foundational for engagement and learning (i.e., Vygotsky, 1978; Dewey, 2001).

The findings of this dissertation have theoretical and practical implications for the fields of online and distance education. Each study identified numerous online and remote instructional and pedagogical strategies supportive of K-12 students' engagement when learning online and remotely. More specifically, Studies 1 and 2 provide an in-depth investigation of synchronous class sessions held via videoconference and the use of webcams as instructional tools in K-12 online learning environments. Regarding the added engagement value of more frequent synchronous class sessions: Study 1 identified the average number of hours adolescents spent attending virtual classes after transitioning to learning online was largely not associated with their greater engagement in learning nor their more positive affect during this time. Instead, participating in a relatively equal balance of time on synchronous and asynchronous activities and having a greater variety of learning activities to complete each day appeared to facilitate a more academically engaging and emotionally positive learning experience for adolescent students. Further, teachers' greater clarity of rules and expectations for student remote work, and communication of care for student well-being were associated with adolescent's higher levels of engagement and positive affect post-transition. Conversely, Study 2 identified elementary school students' webcam use in virtual classes as not wholly predictive of how engaged they were in learning; however, did identify *classroom-level* norms of webcam use in virtual classes are predictive of children's' individual achievement. These findings then identify several practical suggestions for K-12 educators to consider when planning online courses or upon needing to shift to online learning.

Other implications

This dissertation provides a substantive contribution to the COVID-19 remote learning literature due to the time span, sample size, and population (e.g., K-12, rural) that it studies in

relation to the topics of interest (ERT, webcam use). Each study includes a sizable sample of students in comparison to previous studies conducted during COVID-19 on these topics (~2,000 total across studies, grades 3-12). Thus, it could be the findings of these studies have somewhat better generalizability. Further, these studies describe the COVID-19 emergency remote learning experiences of a rural population of students, an historically underrepresented student demographic among the education literature as well as one of unique interest to the education community regarding their remote learning experiences. Prior COVID-19 studies identify rural student populations as exhibiting unique differences in the online and remote learning they received throughout the pandemic (Garet et al., 2020).

Each study incorporates well-established measures from the field of education psychology (i.e., behavioral and emotional engagement, and positive affect) to define desirable educational outcomes for youth. Thus, its findings designate factors which supported these constructs of interest to the education community and are comparable to the large bodies of work that are dedicated to their study (e.g., engagement literature).

Another strength of this dissertation is that each study pushes beyond simple descriptions of the emergency remote learning experiences K-12 students participated in during this time by tying these descriptions to youth's educational outcomes, thus identifying instructional, pedagogical, and contextual supports associated with K-12 students' adjustment (academic and psychological) immediately post-transition and while learning remotely throughout the next school year. Current literature on COVID-19 emergency remote learning typically identifies *perceptions* of what worked during COVID-19 remote learning, likewise, oftentimes the most convenient samples to obtain were the perceptions of undergraduate students, educators, and parents and not K-12 students (e.g., Almahasees et al., 2021; Elmer et al., 2020; Fabriz et al.,

2021; Nilsberth et al., 2021; Whalen, 2021; Trust & Whalen, 2021; Domina et al., 2021). Study 1 identified ERT practices associated with adolescents' higher levels of engagement and positive affect after shifting to remote, in addition to providing a descriptive profile of what a typical day of remote learning was like for them at the onset of the COVID-19 pandemic. Study 2 provides a descriptive profile of class- and student-level influences on elementary school students' webcam use in virtual classes, yet also ties these to children's perceived engagement and achievement (state achievement test scores (MSTEP)). These studies also elaborate the relative importance of home, school, and students' individual choices and daily behaviors in their academic and psychological well-being during this time. Thus, this dissertation (and its studies) meets and exceeds the explanatory capability of many of the descriptive studies currently available regarding effectively engaging K-12 ERT and online learning throughout the COVID-19 pandemic.

Appendices

4.1 Appendix A. Study 1 ERT Measures Included in the PCA Model

ERT measures were organized into two categories: pedagogical experiences (i.e., specific teaching methods/practices and the underlying pedagogy of the ERT they experienced) and instructional experiences (i.e., quantity, quality, and variety of synchronous and asynchronous activities they participated in and for different lengths of time during their typical day remote learning).

Pedagogical experiences

Teacher communication of care

Students' perceptions as to how often their teacher(s) were flexible and understanding with deadlines, how often they communicated care for students' well-being, communicated what they were learning remotely with their parents/guardians, and how frequently they expressed interest in students' academic success. Aggregated from students' responses to four statements (scale of 1-5, *never or almost never - always or almost always) (*α=.70)

Teacher clarity of rules and expectations

Students were asked how often their teacher(s) were responsive to their requests for help with schoolwork, how often they provided actionable feedback regarding their work, and how often they made clear what they expected of them for their classes. Students responded to each of the three statements on a scale from 1-5, *never or almost never - always or almost always*. (α=.73).

Teacher made the work interesting

A single item assessed how much students thought their teachers had made their schoolwork interesting since the transition to remote learning. Responses were selected on a scale from 1-5, 1 corresponding to "*never or almost never*" and 5 "*always or almost always*".

Instructional experiences

Daily hours spent in live class sessions / on asynchronous activities

Students were asked to type in the number of hours they spent during a typical day of remote learning on each of the following activities.

1. On schoolwork - live class sessions like video calls or other real time interactions
2. On schoolwork - not live instruction, like doing practice problems or watching pre-recorded lectures, labs, online modules, and/or completing assignments

Perceived quality of live class sessions / asynchronous activities

Quality of synchronous and asynchronous learning activities was assessed by asking students how much time they would *ideally like to spend* on synchronous or asynchronous work per day while they were remote learning. Students were provided the following prompt: "*Think about your typical and your ideal school day AFTER the transition to remote learning. How many hours* ***have you spent*** *engaged in the following activities, and how many would you* ***ideally like to spend*** *(over a 24-hour period)?"* Difference scores were calculated by comparing the ideal number of hours a student reported to the typical number of hours they reported spending in each respective activity. Wanting to spend *more* or *less* time in synchronous class sessions per day indicating students perceived their synchronous class sessions were of *higher* or *lower* quality.

Variety of online learning activities

Students were asked to check the box to indicate whether they had participated in 5 different online learning activities while learning remotely. The sum of "yes" responses (i.e., checked

boxes) were used to calculate this measure. Observed scores ranged from 1 to 8, with a mean of 4.04.

1. Had a real-time full class session via video call your teacher and all of your classmates (e.g., Zoom, Google Meet, etc.)
2. Had a real-time, small group session, like a video call with your teacher and small group of your classmates
3. Watched pre-recorded videos or learning modules
4. Posted assignment(s) to an online forum
5. Participated in online exercise or mindfulness activity (e.g., yoga class, Go Noodle, meditation, etc.)

Variety of offline learning activities

Students were asked to check the box to indicate whether they had participated in 3 different offline learning activities while learning remotely (see below). The sum of "yes" responses (i.e., checked boxes) were used to calculate this measure. Observed scores ranged from 0 to 2, with a mean of .70 among students.

1. Completed assignment(s) on paper (e.g., worksheet(s), workbook(s), or paper packet(s))
2. Created/presented art or a project
3. Participated in offline activities such as reading a book, a science experiment, or art project at home

Opportunities for academic peer interaction

Students were asked to rate statements relative to two time points in their lives. First, they were asked to rate three statements thinking about how often the following opportunities *before* they had transitioned to learning remotely (i.e., while learning in-person). Then, they were asked

to rate the same three statements again in a separate column, but now thinking about how often they had these opportunities *currently*, while learning remotely.

Statements asked students how often they were 1.) provided opportunities for learning with peers (for example, games like Kahoot! or small group projects); 2.) shared or discussed ideas with partners, small groups, or in real-time class meetings; and 3.) encouraged to ask classmates for help with work if they needed it. Students responded to each statement on a 5-point scale (1 = *never*, 5 = *all the time)*. The first set of responses were aggregated to measure students' opportunities for academic peer interaction while learning in-person ($\alpha = .78$); the second set of responses were aggregated to students' opportunities for academic peer interaction while learning remotely ($\alpha = .76$). Opportunities for peer interaction while learning remotely were included in the PCA; students' estimates of opportunities for peer interaction while learning in person were included as a covariate in Step 1 of each regression model.

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