viewpoints

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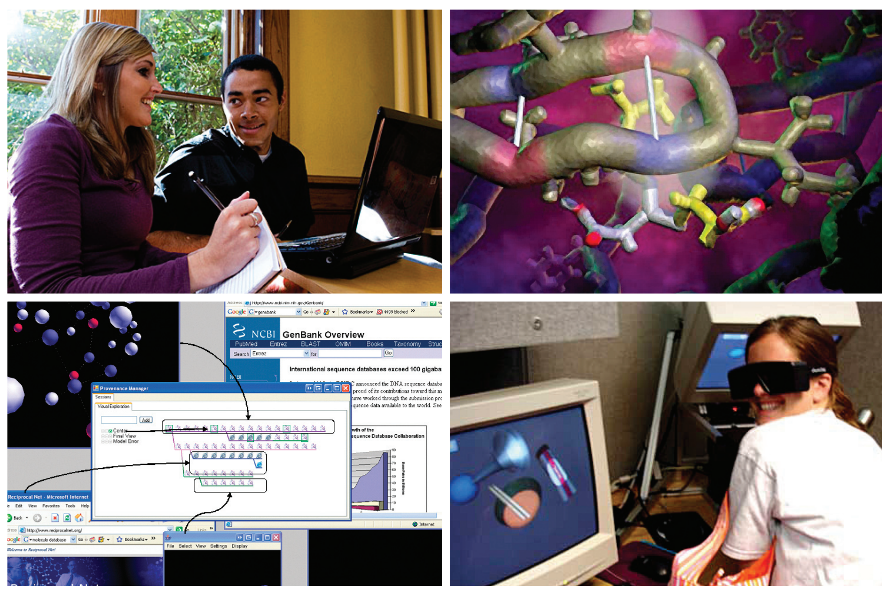
Education

Why an Informatics Degree?

Isn't computer science enough?

WHAT IS AN informatics degree, and why? These are questions that have been posed to us on innumerable occasions for almost a decade by students, parents, employers, and colleagues, and when asked to prepare a *Communications* Education column to answer that question, we jumped at the opportunity.

The term "informatics" has different definitions depending on where it is used. In Europe, for instance, computer science is referred to as informatics. In the U.S., however, informatics is linked with applied computing, or computing in the context of another domain. These are just labels, of course. In practice, we are educating for a broad continuum of computing disciplines, applications, and contexts encountered in society today.



Informatics programs offer diverse applications, as shown in these scenes from the informatics program at Indiana University, Bloomington.

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From Computer Science to Informatics

Computing provides the foundation for science, industry, and ultimately for the success of society. Computing education traditionally has focused on a set of core technological and theoretical concepts, and teaching these concepts remains critically important. Meanwhile, advances in computing occur and are driven by the need to solve increasingly complex problems in domains outside traditional computer science. Students, teachers, and scholars in other fields are keenly interested in computational thinking, and computing itself increasingly is informed by the challenges of other disciplines.

For example, to design good online auction technology, computer scientists found that they needed to understand how humans would select bidding strategies given the system design, and indeed how to design the system to motivate certain types of behavior (truthful value revelation, for example). This co-design problem led to fruitful interdisciplinary collaborations between computer scientists, economists and, increasingly, social psychologists. Likewise, designing successful technology for trust, privacy, reputation, and sharing in social computing environments requires both computer science and behavioral science.

These interactions between problem domain context and computational design are characteristic of the maturing of computer science. Computing is no longer owned solely by computer science, any more than statistics is owned solely by faculty in statistics departments. Computing and computational thinking have become ubiquitous, and embedded in all aspects of science, research, industry, government, and social interaction. Consider the flurry of excitement about "e-commerce" in the late 1990s. Quickly e-commerce moved from being seen as a new field to being absorbed in "commerce": the study of business communications, logistics, fulfillment, and strategy, for which the Internet and computing were just two technologies in a complex infrastructure.

How then does computing education need to change to respond to the new reality, and more importantly, to be equipped to respond to future developments? We must embrace the diversity of ways in which problems are solved through the effective use of computing, and we must better understand the diverse problem domains themselves.

The vision for informatics follows from the natural evolution of computing. The success of computing is in the resolution of problems, found in areas that are predominately outside of computing. Advances in computing—and computing education—require greater understanding of the problems where they are found: in business, science, and the arts and humanities. Students must still learn computing, but they must learn it in contextualized ways. This, then, provides a definition for informatics: informatics is a discipline that solves problems through the application of computing or computation, in the context of the domain of the problem. Broadening computer science through attention to informatics not only offers insights that will drive advances in computing, but also more options and areas of inquiry for students, which will draw increasing numbers of them to study computation.

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Informatics Programs

Computer science is focused on the design of hardware and software *technology* that provides computation. Informatics, in general, studies the intersection of people, information, and technology systems. It focuses on the ever-expanding, ubiquitous, and embedded relationship between information systems and the daily lives of people, from simple systems that support personal information management to massive distributed databases manipulated in real time. The field helps design new uses for information technology that reflect and enhance the way people create, find, and use information, and it takes into account the strategic, social, cultural, and organizational settings in which those solutions will be used.

In the U.S., informatics programs emerged over the past decade, though not always under the informatics name, and often in different flavors that bear the unique stamp of their faculty. Prominent examples include "Informatics" (Indiana University, University of Michigan, University of Washington, UC Irvine), "Human Computer Interaction" (Carnegie Mellon University), "Interactive Computing" (Georgia Tech), "Information Technology and Informatics" (Rutgers), and "Information Science and Technology" (Penn State). Some programs emerged primarily from computer science roots; others from information and social science roots. They do all generally agree on the centrality of the interaction of people and technology, and thus regardless of origin they are multidisciplinary and focus on computation in human contexts.

Informatics is fundamentally an interdisciplinary approach to domain problems, and as such is limited neither to a single discipline nor a single domain. This is evident in another type of diversity in such programs: some take a fairly broad approach, with several distinct tracks or application domains, which can range as widely as art and design, history, linguistics, biology, sociology, statistics and economics. Other programs are limited to a single application domain, such as bioinformatics (for example, Iowa State, Brigham Young, and UC Santa Cruz). Thus, informatics programs can have as many differences as they have commonalities. This has been reflected in some confusion and frustration about how to establish a community of interest. For example, there is an "iSchool" caucus (about 27 members), and a partially overlapping CRA (IT) Deans group (about 40 members). To illustrate some of the issues, we will describe two of the broader programs with which we are most familiar.

The School of Informatics and Computing at Indiana University Bloomington offers a traditional CS degree and an informatics degree, which was first offered in 2000. Its informatics curriculum is focused along three dimensions that are first presented in an introductory course: foundations, implications, and applications. Unlike most traditional computer science curricula, the introductory course does not focus on programming as the sole problem-solving paradigm. Instead, a number of skills, concepts, and problem solving techniques are introduced and motivated by context-based problems, including logical reasoning, basic programming, teamwork, data visualization, and presentation skills. Following this introduction, foundations courses include discrete math and logical reasoning, a two-course programming sequence, and a course on data and information representation, while implications courses include social informatics and human computer interaction. The foundations topics are similar to those in a computer science program; however, the ordering is quite different, in that programming comes last rather than first. This sequencing increases retention in the major because students have more time to develop their technical skills.

At Indiana, the interdisciplinary component of the curriculum is accomplished through a mixture of three methods: elective courses covering technology use and issues in specific problem domains; a required senior capstone project, aimed at solving a "real-world" problem; and a required cognate specialization of at least five courses in another discipline. There are currently over 30 different specializations from around 20 disciplines available, including: business, fine arts, economics, information security, biology, chemistry, telecommunications, and geography.

The School of Information (SI) at the University of Michigan has offered master's and Ph.D. degrees in Information since 1996. In 2008 SI joined with the Computer Science and Engineering Division, and the College of Literature, Science and Arts, to offer a joint undergraduate informatics degree. To enter the major, students are required to complete one prerequisite each in calculus, programming, statistics, and information science. They then take a 16-credit core in discrete math, data structures, statistics, and information technology ethics. Each then selects a several-course specialization track, which is interdisciplinary but focuses on providing depth in a particular domain: computational informatics, information analysis, life science informatics, or social computing. This program establishes a strong foundation, domain depth and interdisciplinary training. However, to accomplish all of this, it also imposes on students the heaviest required-credit burden of any liberal arts major.

The equal participation by the Computer Science and Engineering Division in the Michigan degree emphasizes the ability to design an informatics program as a complement to a traditional computer science degree; indeed, the Computer Science and Engineering Division continues to offer two traditional CS bachelor's degrees (one in engineering, one in liberal arts). One advantage expected for the contextualized informatics degree is higher enrollment of women, and indeed, about half the class of declared majors is female. On the downside, managing a degree that spans three colleges and schools is challenging, with natural hurdles such as teaching budgets and credit approvals across units.

Looking Forward

Informatics curricula are young and developing, but have proven popular. Indiana has over 400 students in the major. In just its first year, Michigan attracted 40 undergraduate majors. Evidence comes also from successful courses offered outside a formal informatics program. For example, a computer scientist and an economist at Cornell enroll about 300 students annually in interdisciplinary "Networks," which counts toward the majors in Computer Science, Economics, Sociology, and Information Science.[a] At the University of Pennsylvania, "Networked Life" (taught by a computer scientist) attracts about 200 students, and satisfies requirements in three majors: Philosophy, Politics, and Economics; Science, Technology, and Society; and Computer and Information Science.[b]

Informatics enables students to combine passions for both computation and another domain. Since almost all domains now benefit from computational thinking, an informatics program can embrace students and concentrations in art and design, history, linguistics, biology, sociology, statistics, and economics. This diversity has costs, of course. One is that for now, in the early years, students and faculty must continuously explain "informatics" to potential employers. Another is providing strong enough foundations in both computation and another discipline to produce competitive, successful graduates.

The desire to deeply understand how computing works is what has drawn most researchers to study computer science. These same individuals are then invested with the responsibility to develop curricular programs and teach computing to the next generation of computing professionals. The current (and all future) generations of students entering the university have largely grown up in a world where computing is so commonplace that it is taken for granted. Many of them are less interested in how computing works than in how to make it work better in the solution of specific problems, drawn from virtually all other domains of human knowledge. There will always be a need for students who study computer science. Informatics provides a complementary path to reach other students for whom understanding and developing computation *contextually* is crucial to the problems that motivate them. Like mathematics, probability, and logic, in the future computation science will be taught embedded in many other areas. Indeed, informatics is a path within which the technical accomplishments of computer science, mathematics, and statistics become embedded in the ways we interact, imagine, and produce throughout the scope of human experience.

a See http://www.infosci.cornell.edu/courses/info2040/2009sp/
b See http://www.cis.upenn.edu/~mkearns/teaching/NetworkedLife/

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