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Abstract

The pervasiveness of computers in modern life has created a need for greater diversity in the knowledge and skills of information/technology professionals. We, as well as others, have identified an IT education gap between the technical focus of computer science degrees and the business focus of MIS concentrations. We describe a new interdisciplinary curriculum (a Bachelor of Science in Information Science) that Northeastern University has developed to fill the IT education gap. The new degree draws from computer science, business, and behavioral science, offering a balance between the technical, functional, and human dimensions of information/system analysis and design not found in other undergraduate programs. It encompasses three broad content areas: computer technology, information systems and human/organizational context. In addition, students acquire the analytical models and tools needed to approach the content areas from a conceptual perspective. An experiential learning requirement enables students to apply their classroom knowledge and skills in relevant productive work. In the future, academics and practitioners need to work together to better articulate new career paths for information/technology professionals and the appropriate educational programs to serve their needs.

Introduction

We are now living in an information society, a society in which computer-based information technologies affect almost every aspect of our lives, from marketing and e-commerce using the World Wide Web, to automated income tax filing and the administration of government benefits, to multimedia applications in music, film, education, medical diagnosis, and weather forecasting. Whether one works in business, science, engineering, law enforcement, health care, entertainment, education, or any other field, it is virtually certain that she or he will interact with computers. And it is also virtually certain that at some point she or he will turn to an information/technology professional for assistance.

Thus, we see the information/technology profession growing in concert with the information society.

It is, therefore, ironic that during a time of unprecedented opportunity, the information/technology field should be "in crisis." The significant problems facing the I/T field range from system failure rates to software quality concerns to societal issues to the I/T worker shortage (Cone, 1997; ITAA, 1998). What all of these issues have in common is their relationship to another significant challenge facing the I/T profession: the development of appropriately educated I/T professionals. This paper addresses the educational challenge facing the I/T profession in the United States.[1] It does so in the following way. First, we articulate the I/T educational need by highlighting the gap in current curricula. We then present a vision of I/T education (and a curriculum we have developed) that responds to this gap. Finally, we suggest some issues for the future.

Dimensions of the Need

The pervasiveness of computers in modern life has fundamentally changed society. It has also created the need for a greater diversity of information/technology professionals. This diversity has resulted from the growth of knowledge at both the technical and the behavioral ends of the knowledge/skill continuum. Consequently, no single individual can possess all the knowledge and skills needed by the I/T profession. Similarly, we believe, no single curriculum can cover the entire I/T educational spectrum. At one end of the information/ technology spectrum, computer science graduates are skilled in software development, systems and network management, and technical trouble-shooting. At the other end, MIS graduates understand how to achieve business goals and enhance business functions through the application of information resources and technology.

While both MIS and computer science curricula are successful in their own rights, and are educating I/T professionals for particular aspects of the I/T field, the information society is putting increased pressure on I/T education to fill the gap between computer science degrees that emphasize technical concerns at the expense of contextual knowledge, and MIS concentrations that focus more attention on business considerations at the expense of technical depth.. There is a need for professionals who have more behavioral and contextual understanding than computer scientists yet have more

technical knowledge than an MIS concentration within a business degree allows.[2] Thus, the profile of a new type of I/T professional is emerging (Dahlbohm and Mathiassen, 1997). Such individuals must be able to provide detailed logical designs, plan and manage system development efforts, and evaluate the impact of information systems. In addition, they must be aware of how the assumptions and values of a variety of application contexts -- in health care, government, education, science, engineering, and the arts/humanities in addition to traditional business -- influence the functional and technical requirements that a system design must satisfy.

This new category of information/technology professional will focus on the application side of computing, including issues of usability and organizational impact. Their challenge will be to design and develop applications that balance intended benefits against unintended harms. Three types of expertise are needed for such work in the I/T profession. The first is *technical.* This is an understanding of how computer and communication technology works, and how to program and design software, databases, and networks. The second is *information systems.* This area of expertise includes the ability to analyze the information goals of users, as well as skill in the design and development of technology-based systems solutions. The final area of expertise is *context*. This includes the ability to recognize and respond to organizational, behavioral and policy issues that arise in the creation and use of information systems.

The educational challenge that has been articulated throughout the last decade is to create a program that produces graduates who have a sophisticated understanding of information processing in both the technological and human dimensions, and the problem-solving skills to make technology work effectively in a variety of human contexts (Feeney and Willcocks, 1998; Freeman and Aspray, 1999; ITAA, 1998; Lee, Trauth and Farwell, 1995; National Information Technology Workforce Convocation, 1998; Sawyer, 1998; Trauth, Lee and Farwell, 1993).

An Educational Response: Interdisciplinary Information Science

Northeastern University has chosen to respond to the IT education gap by developing an interdisciplinary degree in Iinformation Science that draws from computer science, business, and behavioral science. While a number of labels are emerging to describe this new educational space,[3] we have chosen the label *information science.* The objective of the Information Science at Northeastern University is to offer a program of study for students who want to pursue careers that combine the technical and behavioral perspectives on information systems. These would include careers as information system architects and designers, application software or data management specialists, World Wide Web site designers/managers, information policy analysts, usability specialists, and other career paths that focus on the acquisition, organization, use and impact of information per se and information/technology and its applications.

Over the past thirty years information science has been emerging as an interdisciplinary field that draws upon concepts and methodologies from computer science as well as behavioral science. As an emerging field, it does not yet have a national consensus regarding its scope and definition. However, all parties in the discussion agree that, in contrast with computer science and engineering, which focus on the artifact and its behavior, information science focuses on the relationship between information/technology and the people who interact with it.

Like computer science, information science occupies an intermediate point between a liberal education and a professional degree. It includes professional skill in information analysis, design of information systems, computer programming and software engineering. It also includes technical knowledge of the principles of computer systems, algorithms, database management, and communication networks. Finally, it includes an understanding, rooted in the behavioral and social sciences, of the mutual impact between information systems and their surrounding context: the people, organizations, and societies that use them.

The scope of information science cuts across traditional academic disciplines. Topics such as human information processing (from psychology), organizational behavior and strategic management (from business) and empirical research methods (from social science) sit side by side with the study of mathematics, and computer programming, object-oriented design, database systems and computer networks (from computer science). This knowledge from both computer science and social science provides the background for advanced courses in information system analysis and design, human-computer interaction, information resources management, and social impact of computers.

Emphasis on balance

The field of information science takes a holistic view of information systems that includes the information contained in the system, the computers and networks that store and process the information, the users who interact with the system, and the clients or customers for whose benefit the system was created. From this perspective, there are three dimensions of information system performance that I/T professionals must be concerned with: the functional dimension, the technical dimension, and the human dimension.

The functional dimension of an information system focuses on the objectives envisioned by the client or customer. A system that solves the wrong problem, provides the wrong information, requires information that

is not available, or includes subsystems that are not compatible, is not a success regardless of its other attributes. The technical dimension of a system includes its correctness (relative to its design specifications) its reliability, and its efficiency in using computing resources (memory, processing power, etc.) The human dimension of an information system includes its usability and its compliance with the legal, ethical and policy requirements of the client or customer (and of society at large). Figure 1 shows the proportion of time devoted to each of the three dimensions in the information/technology related courses of a typical computer science curriculum, a typical MIS concentration4 and the information science curriculum at Northeastern University. A noteworthy feature of the information science curriculum is the balance achieved between the need for a high degree of technical competence and the need for I/T professionals to take account of the organizational and social environment that ultimately determines the success of their work

Content areas of required courses

The three areas of expertise – technical, information systems, and context – provide the framework for the content areas of the required courses. An understanding of technology and programming (beyond 5 prerequisite computer science courses) is developed through courses on database design, telecommunications design and applications, and computer networks. An understanding of information systems begins with the Principles of Information Science course, continues with courses on information system analysis/design and information system development, and is completed in the Senior field study project course.

The context dimension of this curriculum is provided in several ways. Following prerequisite courses in social science, psychology, cognition and organizational behavior, are specific required courses that focus on information systems/technology in a human context. These courses address context at different levels of analysis: the individual (Human-Computer Interaction course), the organization (Information Resource Management course), and the society (Computers and Society course).

A second way in which context is addressed is through the two courses which frame the degree. The introductory course at the beginning of the program (Principles of Information Science) introduces the student to this subject matter as inherently about I/T in context. Students learn about information processing and communication systems from the perspective of the technology which provides the information, the human who uses it, and organizations, industries and societies which are affected by it. At the end of the program is a two-course sequence (Information Science Field Study and Information Science Senior Project) which serves as the capstone of the degree. Students go into the field in order to observe and analyze information processing and communication behavior in some real-world context. In these courses students learn to observe and critically consider the way in which context influences the use of I/T in some particular setting and the impact that I/T has upon that context.

The final component of the required coursework is aimed at developing the conceptual and analytical tools necessary to understand about the interactions among the technology, the people, and the context. Specifically, students will develop the tools for data collection, analysis and interpretation. These skills are developed through a prerequisite statistics course followed by a required empirical research methods course. Using a wide range of quantitative and qualitative methods, information science students will learn to analyze and evaluate information requirements, processes and systems, and explore issues related to their usability, effectiveness, and impact. The tools they will use span the spectrum from mathematical modeling, to statistical analysis of experimental data, to inductive methods such as surveys, case studies, and ethnography.

Experiential Learning

In order to accomplish the field-based learning experience, we draw upon the cooperative education philosophy at Northeastern University, which was one of the first universities in the United States to incorporate experiential learning into its curriculum. From the outset, practice-oriented learning was an essential component of.the Information Science curriculum design. The philosophy of cooperative education is based on work-integrated learning: the alternation of full-time work and full-time study over a series of terms. Each coop working term assists the student in developing and enhancing the skills necessary to take advantage of the learning opportunities inherent in the curriculum.

Experiential learning provides an opportunity for students to combine their classroom knowledge and skills in collaboration with one or more employing organizations in relevant, productive work. It is anticipated that each coop period will provide an environment within which a student will be able to apply theory and concepts in a work setting. Over a series of coop experiences, a student will be expected to demonstrate reasonable mastery of skills necessary for success in the IT workplace: technical application, problem solving, professionalism, oral and written communication, effective work habits, and sensitivity to ethical and societal impacts.

Experiential learning also provides an opportunity for students to observe, first-hand, the importance of

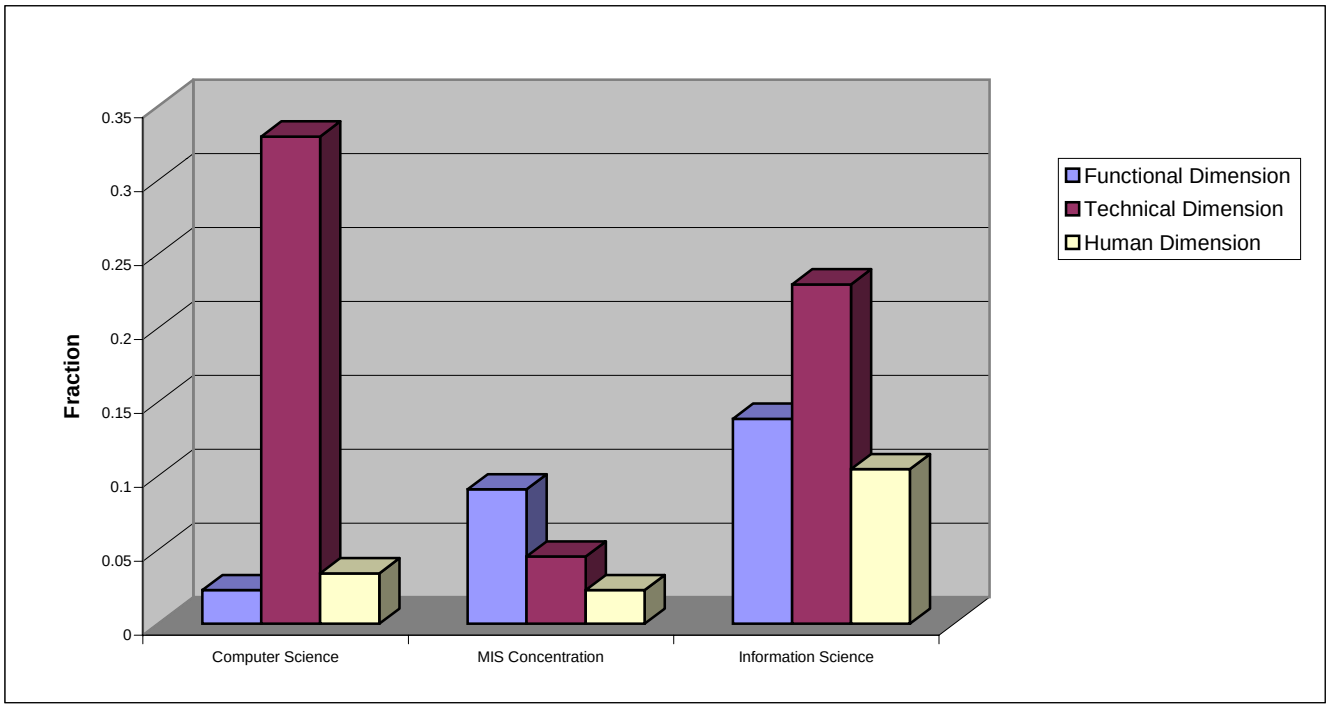

Figure 1. Comparison of typical Computer Science degree, MIS concentration, and proposed Information Science degree. The fraction of each program devoted to each of the three dimensions of IT performance is shown. The functional dimension of an information system focuses on whether it achieves the objectives envisioned by the client or customer. The technical dimension of a system includes its correctness, reliability, and efficiency. The human dimension includes its usability and its compliance with the legal, ethical and policy requirements of the client or customer and society at large.

organizational and social context to the successful use of information technology. Classroom examples and exercises that explore the relationship among the functional, technical and human dimensions of information systems are reinforced and the students' understanding is deepened as they experience this relationship within the particular organizational and social environment of their coop work assignment.

Implementation

Northeastern's implementation of the Information Science curriculum framework is shown in Figure 2, with specific course titles. The program was approved in Spring, 1999; students will begin taking information science courses in Fall, 2000.[5] The curriculum shown here is the result of a 2-year project that focused on both the needs of industry (Trauth et. al. 1993, Lee et. al. 1995) and the conceptual issues involved in designing a curriculum that integrates the technical and behavioral perspectives, as described above.

The curriculum was designed by the authors with the assistance of a University-wide faculty advisory committee, which included representatives from business, computer science, psychology, sociology, engineering, the university library, and the division of cooperative education.

In addition, visits to several large and small companies in the Boston area were made to solicit their advice, in once case resulting in a 3-year grant to support the development of the new program.

The course requirements shown in Figure 2 demonstrate some differences bewteen the Information Science curriculum model described here and the emerging standard for Information Systems curricula, as described in IS-97[6]. One difference is the more rigorous approach to the study of mathematics and computer science, which is appropriate for a science (as contrasted with a professional) degree program. Another is the focus on the individual and societal levels of context, in addition to the organizational level, with required courses in human-computer interaction and computers and society. Finally, the emphasis on formal evaluation of information systems and technology (their usability, organizational effectiveness, and societal impact), using the methdologies of the behavioral and social sciences, is unique in this program.

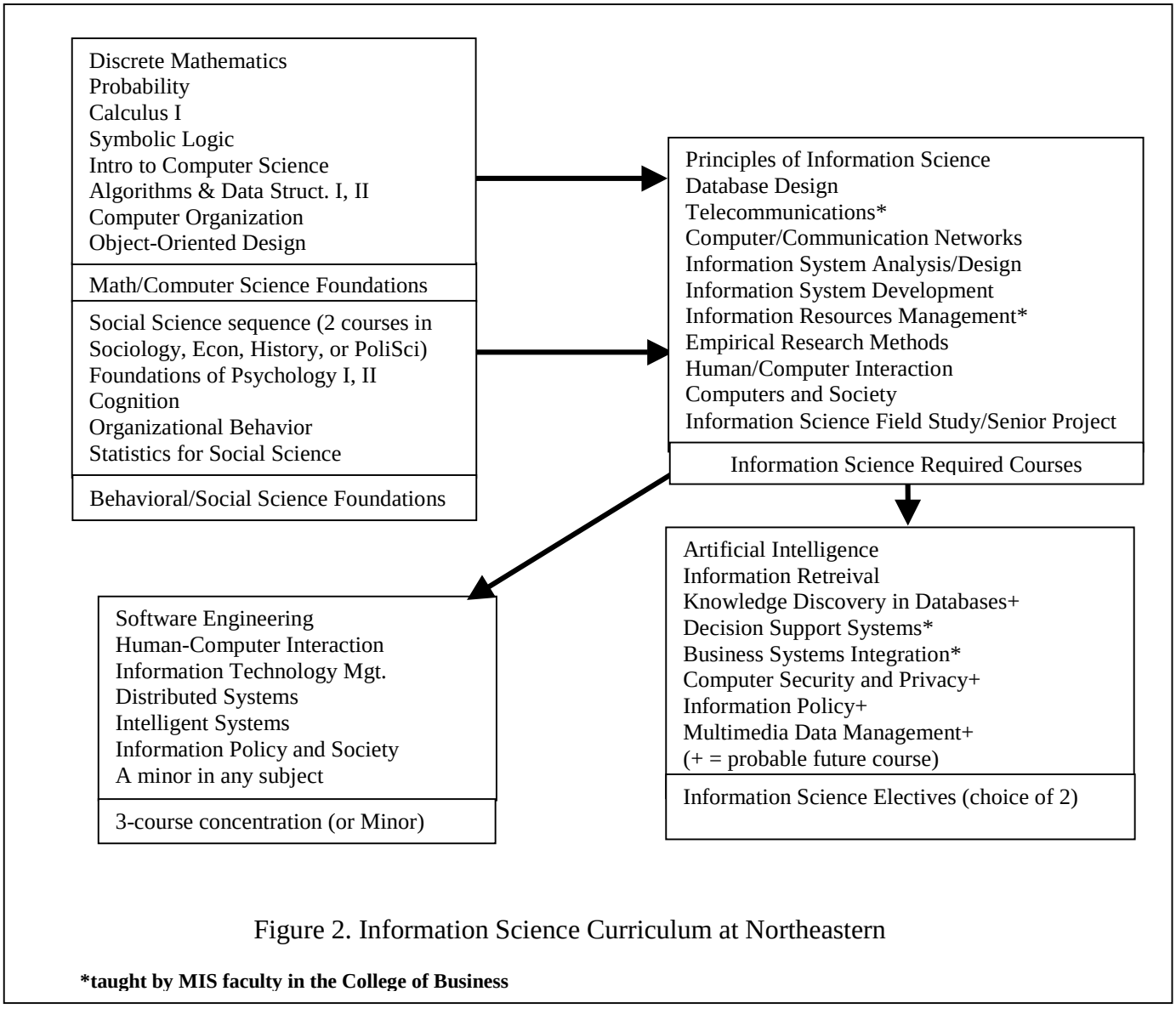

Figure 2. Information Science Curriculum at Northeastern

***taught by MIS faculty in the College of Business**

Conclusions

The demand among students for information technology education is not limited to those wishing to major in information science. Other disciplines can develop tracks, minors, and/or dual degrees in information science. The creation of a flexible framework for cooperation with other academic areas to satisfy these demands is a high priority in the evolution of this degree program. For example, a dual degree with the College of Business Administration is one of our top priorities in this area.

In addition to the need to create appropriate educational programs are another set of issues. These issues need to be addressed by both the academic and the practitioner communities. If not adequately addressed they can undermine the best I/T curriculum efforts. One issue is about career paths. Despite the quality of an undergraduate curriculum, if students cannot envision a career path (or if they do not like what they see) they may decline to enter the field. Therefore, both practitioners and professors need to work together to better articulate the new career paths in the I/T profession. The second issue is about keeping up with the pace of technological change. The dynamic nature of the I/T profession means that curricula cannot afford to be static. It must change as new techniques, technologies and insights emerge. Practitioners can help academics in this effort to remain current. The final issue is about lifelong learning of the IS professional. Despite the quality of a baccalaureate degree, the explosive growth of knowledge requires that I/T professionals engage in continuous learning. Educators need to make sure that mid-career professionals

receive continuous learning so that they continue to be vibrant contributors to their profession. Therefore, built into any B.S. degree needs to be a vision of post-graduate education. This can be accomplished through a mixture of degree- and non-degree courses of study.7 The practitioner community can participate through input to curriculum decisions and by encouraging I/T professionals to avail themselves of such programs and supporting them when they do.

Acknowledgements

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Notes

[1] Because I/T education is enacted in different ways in different countries this paper speaks only to the situation in the US. To the extent that universities in other countries have I/T curricula similar to that in the US, the suggestions offered in this paper may be applicable to them.

[2] For example, MIS programs in business schools would be constrained in their efforts to implement the recommended curriculum "IS-97" (DPMA, 1997) because of the requirements regarding other business and nonbusiness courses. See also NSF (1993).

[3] Another term that is being used in the US is *informatics*. Indiana University, for example, has developed an interdisciplinary approach with a new School of Informatics and the National Science Foundation (1993) has articulated a vision of information specialists using this term. However, because of the highly technical connotation of the term in other countries and the inherent interdisciplinarity connoted in the term *information science* we have chosen to use the latter term along with other institutions such as Penn State and Temple University.

[4] It is assumed that such MIS programs are situated within a college or school of business and, hence, are constrained in terms of the number of I/T courses that can be required.

[55] Students entering the College of Computer Science take a common set of courses in the Freshman year, and decide whether to major in Computer Science or Information Science in the sophomore year. The first class of Information Science Students will number about 30.

[6] Soon to be supplanted by IS-2000. See: http://www.IS2000.org/

[7] For example, we have been offering a Graduate Certificate in Information Resource Management since 1995 that combines courses in MIS with those in computer science.