IS Grows Up and Leaves Home: Situating Educational Programs in the Information Society

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Abstract

The pervasiveness of computers in modern life has created a need for greater diversity in the educational frameworks for information technology education. We describe a new educational framework (a Bachelor of Science in Information Science) developed at Northeastern University, which focuses on the relationships between information, technology and users, and encompasses today's diversity of application domains. The framework focuses on the design and use of information systems within a science-oriented education paradigm, as contrasted with the professional education offered in schools of business administration. It includes a strong background requirement of technical courses in computer science, along with a strong background requirement in behavioral/ social science. It also addresses the wide variety of domains and contexts in which information systems are now used, including but not limited to business. The study of empirical research methods give students the ability to conduct objective, systematic evaluation of the usability and/or impact of information technology, while an experiential learning requirement enables students to apply their classroom knowledge and skills in relevant productive work. Assessment of learning outcomes is one of the challenges we face as the implementation of the program proceeds.

Keywords: IT Education Framework, Interdisciplinary Curriculum, Information Science

1. INTRODUCTION

In today's information society, the impact of information technology (IT) is felt in 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. The pervasiveness of information technology is motivating both quantitative and qualitative changes in information systems education. This paper addresses one of the qualitative changes: the evolution of information systems from a sub-area of business and computer science into a discipline in its own right with its own educational framework.

Traditionally, undergraduates wishing to major in information systems have two choices:

- computer science programs that focus on the theoretical and technical foundations of computer systems and sofware development, with related courses in mathematics, physics and electrical engineering;
- MIS programs in schools of business that focus on achieving business goals through the application of information technology, with related courses in business functional areas including finance, accounting and marketing.

While both MIS and computer science curricula are successful in their own right, and are educating students for important roles within the IT field, there is an educational gap between these two alternatives.

From a historical perspective, it is easy to see how this educational gap arose: thirty years ago, computers had only two significant applications: scientific data analysis and business data processing. In that world, the fields of MIS and computer science were born, offering programs rooted in their parent fields of business and physical science/mathematics. The curricula for both computer science and MIS have evolved (Turner 1991; IS-97) and continue to evolve (ACM et. al. 2000; IEEE and ACM 2000) to reflect the growth of knowledge in their respective fields; however, these improvements only marginally address the IT education gap.

Today, the computer revolution has created a need for a more diverse approach to IT education. It is time for information systems education to grow up and leave home – to develop an independent identity, while still retaining close family ties to the parent fields of computer science and MIS.

The thesis that there are gaps in IT education is not a new one: in recent years, both academics and employers have increasingly recognized the need for innovation (Dahlbohm and Mathiassen 1997; El-Rewini et. al. 1997; Kling 1993; National Science Foundation 1993; Trauth et. al. 1993). In response, several universitites have initiated new programs, and others are making plans to do so.

This paper addresses the challenge of creating a conceptually and pedagogically motivated solution that can fill the gap in IT education. It does so in the following way. First, we analyze the IT education gap and identify goals for the new program. We then present our solution: a framework for undergraduate education that focuses on the relationships among information, computers, and people, and encompasses today's diversity of application domains. The framework has been implemented at Northeastern University as a Bachelor of Science degree in Information Science, offered beginning Fall 1999. Finally, we discuss some directions for future work.

2. BRIDGING THE IT EDUCATION GAP

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 concentrations teach students to achieve business goals and enhance business functions by the application of information resources and technology. Between these alternatives is a gap, which is growing in importance as information technology and its applications become more pervasive and more complex. The gap occurs where the functional requirements of an information system need to be expanded into a detailed data model and task structure design for software developers to implement. The gap also occurs where organizational structures and policies need to be reflected in the design and performance of its information systems. Finally, the gap occurs where there is a need for objective, systematic assessment of the usefulness, usability and impact of information systems.

The information science framework described in the next Section aims to bridge this gap; its graduates are qualified to be "information architects" who, like traditional architects, analyze the needs and behavior patterns of a client, and create a detailed blueprint to be followed by the builder. Its graduates are also qualified to be involved in IT planning, evaluation, and policy analysis. Their high level of both technical and behavioral sophistication will be an advantage in all of these roles.

More specifically, to fill the IT education gap, a program is needed that focuses on:

- the design and development of information systems, supported by a strong technical background in mathematics and computer science.
- the use of information systems within a science-oriented education paradigm (as contrasted with the professional education offered in schools of business administration), supported by a strong background in behavioral/social science.
- the wide variety of domains and contexts in which information systems are now used (including but not limited to business).

Northeastern University has responded to the IT education gap by developing an interdisciplinary degree that draws upon concepts and methodology from computer science, business, and behavioral/social science. While a number of labels are emerging to describe this new educational space,1 we have chosen the label information science. As an emerging field, information science 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, which focuses on the artifact and its behavior, information science focuses on applications of information technology, and the relationships between information, computers, and people.

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 requirements analysis (from business) and empirical research methods (from social science) sit side by side

[1] 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.

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 behavioral science provides the background for advanced courses in information system analysis and design, human-computer interaction, information resources management, and social impact of computers.

The educational challenge that has been articulated during the past decade is to create a program that produces graduates who have a sophisticated understanding of information systems in both the technical and human dimensions, and the problem-solving skills to make technology work effectively in a variety of contexts-- in health care, government, education, science, engineering, and the arts/humanities in addition to traditional business. (Freeman and Aspray, 1999; ITAA, 1998; National Information Technology Workforce Convocation, 1998.)

3. A FRAMEWORK FOR INFORMATION SCIENCE EDUCATION

In this Section, we provide a conceptual overview of a new framework for education in information technology that we believe will meet this challenge. The subject matter covered by the framework includes four areas of expertise. The first is computing technology. 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 and requirements of users, as well as skill in the design and development of technology-based solutions. The third area of expertise is context. This includes the ability to recognize and respond to behavioral and social issues, including usability, organizational effectiveness, and organizational/societal rules and policies. The final areas of expertise is empirical methods. This gives students the ability to perform formal, systematic evaluation of information systems in context.

Just as the subject matter of information science is interdisciplinary, its methodologies span the spectrum from mathematical modeling and formal deduction, to statistical analysis and experimental design, to software design (e.g. object-oriented) methodologies, to inductive methods such as surveys, case studies, and ethnography. Using this range of techniques, information scientists are able to analyze information requirements, design, develop and implement technical solutions, and pose and answer questions about their performance, usability, and impact.

The framework's focus on context and empirical methods along with computer technology and information systems is innovative and essential. If, as stated in a recent IT education workshop report, "large software and hardware systems rarely live up to [users'] expectations" (National Science Foundation 1993, p. 5), then solving this problem will require understanding both the systems side and the users' expectations side. We define context as the total human environment of an information system. It includes three levels: the individual level, which is concerned with the impact of computer applications on users' productivity, effectiveness and well-being; the organizational level, which is concerned with finding system solutions that are compatible with an organization's culture, policies and procedures; and the societal level, which is concerned with the legal, ethical and social policy constraints that apply to an information system, and the impact of information technology on society at large. Lacking adequate explanatory models of human and social behavior, empirical research methods provide the necessary scientific foundations for the study of technology in context.

Figure 1 shows the structure of the Information Science curriculum. It begins with strong foundations in mathematics, logic and computer science as well as behavioral and social sciences. The core courses cover the four broad areas of Information Science: computing technology, information system design and development, human/organizational context, and empirical methods, as described above. However, information science courses do not address just one of these areas; although particular courses concentrate on technology, design, context, or empirical methods, each course includes integrative material as well.

The technical component of the information science core focuses on essential technologies. Required topics are, at a minimum, database systems and telecommunication networks. Additional topics in this category are information retrieval, distributed computing, multimedia systems, and artificial intelligence. The information systems component focuses on the study of information per se: its acquisition, representation, processing, use and impact; and on the design and development of information systems. It includes systems theory, application frameworks from a variety of domains, requirements analysis, logical and physical design, development methodologies, automated tools, and techniques for system evaluation/re-engineering. The human/organizational context component develops in students the ability to recognize and respond to organizational, behavioral and policy issues that arise in the creation and use of information systems. It includes human-computer interaction, social, legal and ethical aspects of computing, and information resources management. The empirical methods component teaches students to use a variety of data collection and analysis techniques from controlled experiments and surveys with statistical hypothesis testing, to ethnographic methods such as interviews and focus groups.

The concentration or minor component of the Information Science framework involves the student's choice of additional depth (a concentration) or breadth (a minor in another subject). Students desiring more

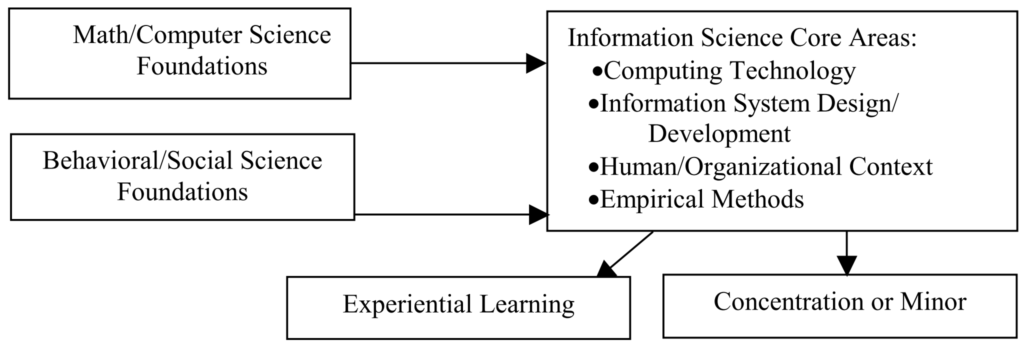


Figure 1. Curriculum Framework for Information Science Education

depth in some aspect of information science (such as software engineering, distributed systems, information systems management, information policy, or human-computer interaction) can follow a pre-defined track in their chosen area. Other students may prefer to broaden their education by completing a minor in a different field – in many cases, the minor field is one in which the student intends to work as an information technology specialist.

The final component of the Information Science framework is experiential learning, requiring professional work experience through an internship or cooperative education plan. (At Northeastern University, a formal cooperative education program exists in which students alternate full-time work assignments with full-time study.) Experiential learning provides an opportunity for students to practice and extend their classroom knowledge and skills in collaboration with one or more employing organizations in relevant, productive work. It also provides an opportunity for students to experience first-hand the relevance of the human/organizational context to the successful development and use of information technology.

4. THE EMPHASIS ON BALANCE

In developing the information science framework, we have adopted 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 IT professionals must be concerned with: the functional dimension, the technical dimension, and the human dimension.

The functional dimension of an information system focuses on whether it achieves 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 sub-systems 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 2 shows the percent of time devoted to each of the three dimensions in the information-technology related courses of a typical computer science curriculum, a typical MIS concentration, and the proposed information science curriculum. Figure 3 shows the overall distribution of topic areas in a typical computer science curriculum, a typical MIS concentration, and the proposed information science curriculum. The unique feature of the information science curriculum, clearly visible in Figure 3, is the balance achieved between the need for a high degree of technical competence and the need for IT professionals to take account of the organizational and social environment that ultimately determines the success of their work.

5. FUTURE DIRECTIONS

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.

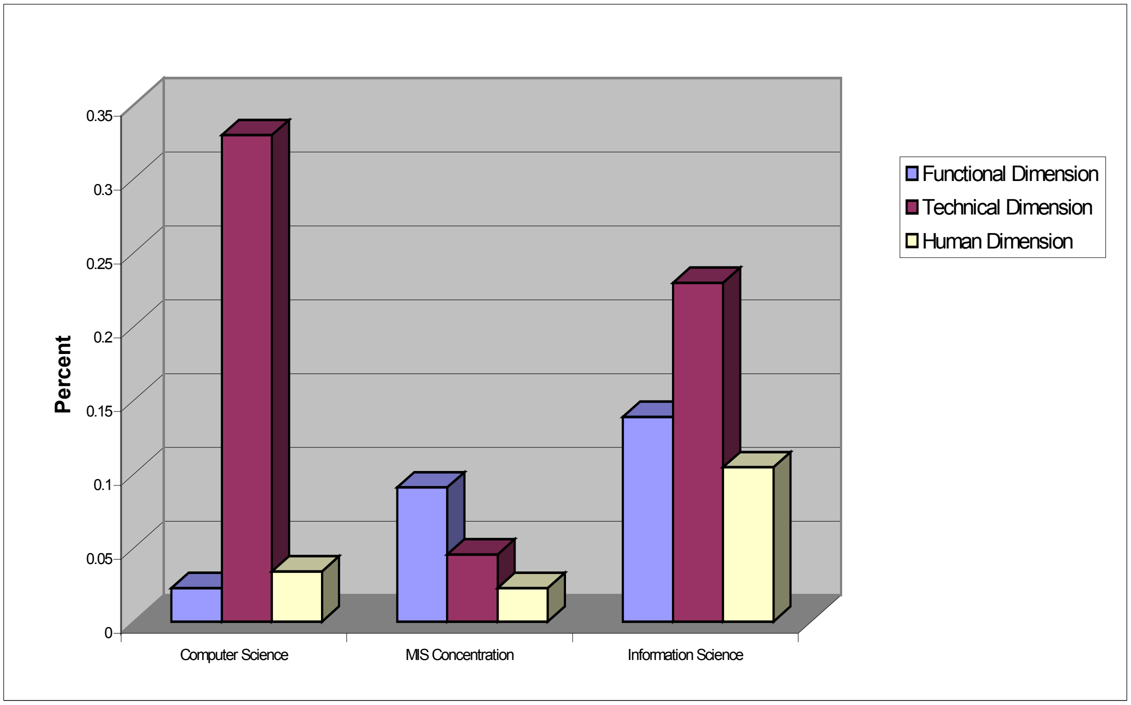


Figure 2. Comparison of typical Computer Science program, MIS concentration, and the Information Science framework. The percent of each discipline devoted to study of the three dimensions of IT performance is shown. The functional dimension of an information system focuses on whether it achieves the 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.

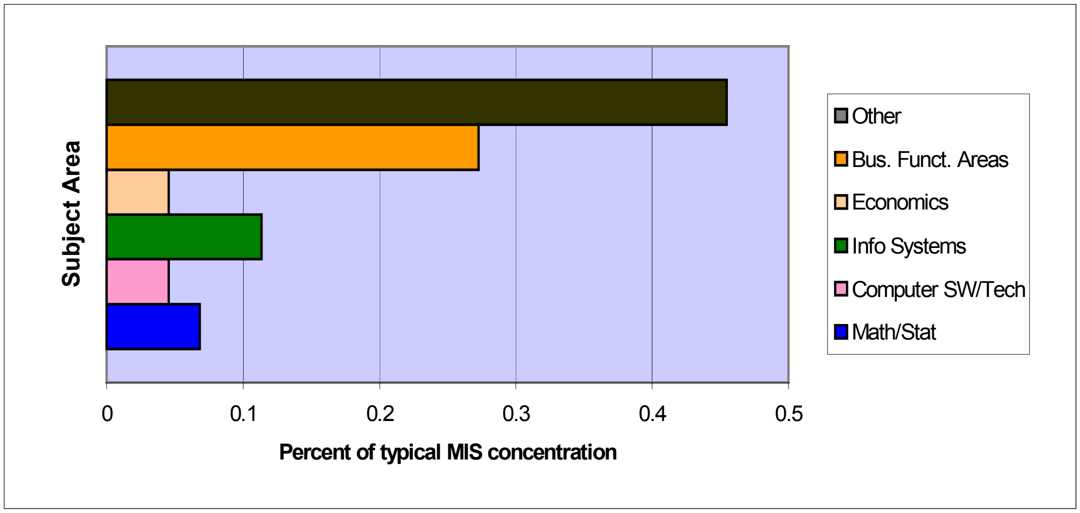
In addition to the need to create appropriate interdisciplinary programs and tracks, another important issue is the lifelong learning of the IT professional. Despite the quality of a baccalaureate degree, the explosive growth of knowledge requires that professionals engage in continuous learning. Educators need to make sure that mid-career professionals receive continuous learning so that they continue to be vibrant contributors to their profession.

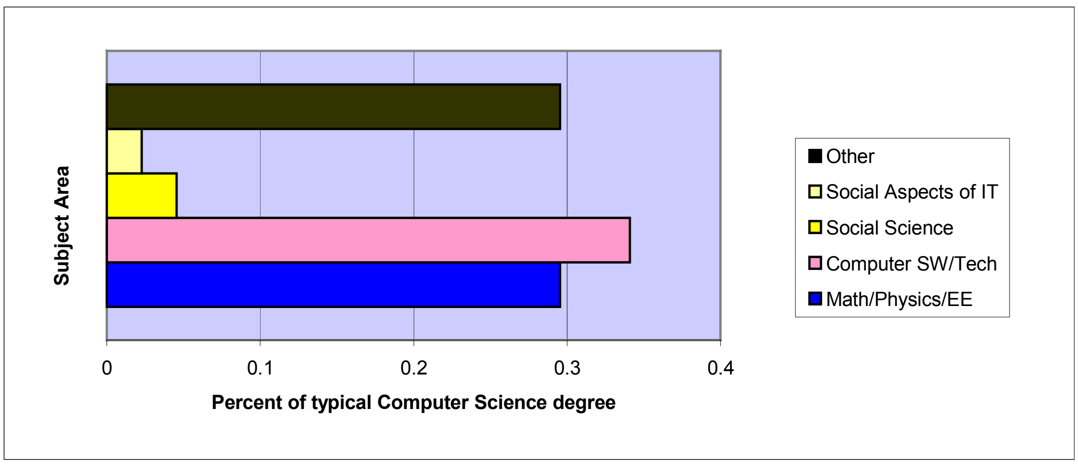
Therefore, built into any B.S. degree needs to be a vision of post-graduate education. This can be accomplished through a mixture of degree- and non-degree courses of study.2

A final issue is the assessment of learning outcomes. Assessing student learning in the information science program presents an assessment challenge. The challenge is to evaluate not only students' mastery of technical skills and knowledge related to computer use and technical system design. These can be assessed through conventional mechanisms such as examinations in discrete courses. The innovative part of the Information Science program is the dual emphases on the technical mastery and context-appropriate design. Thus, the assessment of this program must not only involve evaluation of how well students are acquiring knowledge but also how well they can appropriately apply this knowledge to the requirements of a given human/organizational context. Measuring this type of learning is much more difficult.

Recent work in educational research, however, has focused attention on ways to conduct systematic assessment of the learning process that would be applicable to both narrow and broader, cross-cutting skills and knowledge (Gardiner 1994). One form of assessment we plan to experiment with is the student portfolio. While portfolios have been widely used at the primary and secondary levels for some time, they are a more recent phenomenon at the university level (Black 1993; Forest 1990; Hutchings 1990). The purpose of the portfolio is to document students' progress as they move through the curriculum in specified courses as well as their accumulated progress in attaining mastery of cross-cutting knowledge and skills. Items which may be included in the student portfolio are exams (in both quantitative and essay format), individual assignments ranging from programming assignments to written research papers to feedback on oral presentations, to group project reports.

[2] 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.





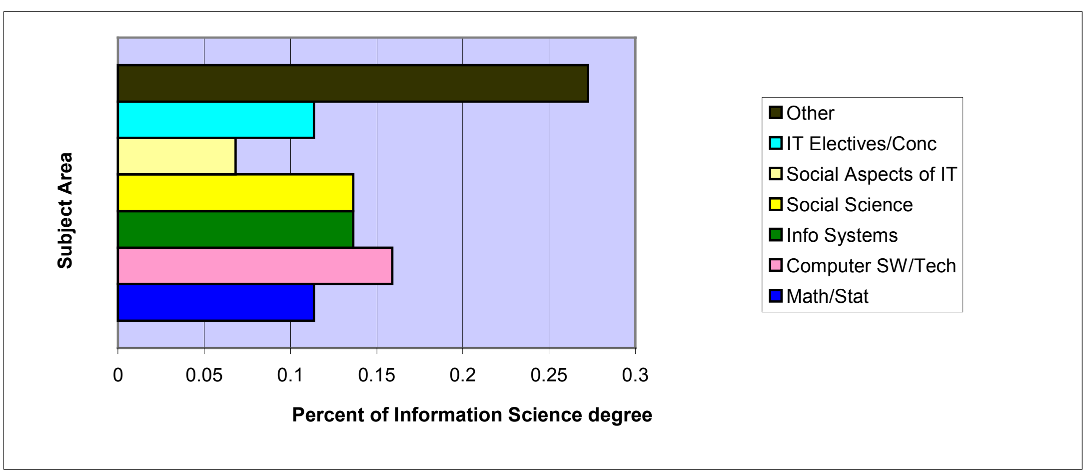


Figure 3. The emphasis on balance between technical and contextual aspects of IT is shown by this comparison of the distribution of subject matter in typical CS and MIS curricula and the proposed Information Science curriculum.

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