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Abstract

We propose the requirements of an information science core that serves as a foundation for the information related disciplines. Based on this core, we present a comprehensive curriculum that covers the entire spectrum of information related activities across disciplines and supports a variety of programs geared to all ages from early school years to retirement and beyond. The complete curriculum has a number of components addressing the needs of learners in a variety of age groups ranging from elementary school through college and beyond. Seven programs, each with a specific emphasis for various groups, are at various stages of development. Such essential issues as industrial-academic liaisons, workforce (re)training, promotional and awareness programs, teacher training, and IT professional role redefinition, are integral pieces of this project. As an example, the version of a concentration program that can be included in an existing MIS program is presented. The specialization courses follow from the proposed information science course.

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Keywords: IT education, information science, conservative logic

Introduction

All projections indicate that the current shortage of IT specialists is expected to only grow larger in the next decade. This shortage is not confined to a specific area of expertise, but goes across all major professions related to IT. The US Labor Department statistics, reported in an August 2000 issue of the BusinessWeek magazine (BusinessWeek 2000) clearly highlights the critical nature of this problem. The analysts rank the IT area as the fastest growing job market with an increase of 94% over a decade (1998-2008). See Table 1a (left). In addition, for the same period of time, the top five professions with fastest growth in the same period are all IT related jobs. Table 1b presents the projected numbers and the percentages of growth for the top five.
Neither the institutions of higher learning nor the industry have taken the sign as seriously as they should. Current IT workforce development efforts are limited to training, and have not as yet focused on education and professional development. Largely, this is due to a lack of a science underpinning for IT related curricula. Without such a unified science component, a structured organization of information related concepts cannot be derived. A major component of this effort has been the development of the science component which is undoubtedly the cornerstone of the entire curriculum.

Table 1. Job Growth Projections for 1998-2008
(Data from the US Labor Department)

<table>
<thead>
<tr>
<th></th>
<th>(A) Top five in total jobs added</th>
<th>(B) Top five in percentage growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jobs added</td>
<td>% growth</td>
</tr>
<tr>
<td>Systems analyst</td>
<td>577,000</td>
<td>94%</td>
</tr>
<tr>
<td>Retail Salesperson</td>
<td>563,000</td>
<td>14%</td>
</tr>
<tr>
<td>Cashier</td>
<td>556,000</td>
<td>17%</td>
</tr>
<tr>
<td>General manager</td>
<td>551,000</td>
<td>16%</td>
</tr>
<tr>
<td>Truck driver</td>
<td>493,000</td>
<td>17%</td>
</tr>
<tr>
<td>Overall</td>
<td>20.3M</td>
<td>14%</td>
</tr>
</tbody>
</table>

Information Science and Engineering is an emerging discipline which provides the forum for convergence of the multi-faceted developments in the area of information in various domains including, computer science, mathematics, electrical engineering, and management information systems. It is timely to raise the question: “What are the necessary skills expected of a graduate who can be employed as an information specialist?” By looking at different disciplines, we see that each offers a specific expertise, which is non-overlapping with other perspectives. For example, information coding theory which is traditionally housed in Electrical Engineering does little to help the student in learning the pragmatic aspects of information. Computer Science programs, through the coverage of data structures and database systems, expose the student to the necessary tools for information modeling, preservation and processing. However, since the primary emphasis is on programming skills and code generation, learning of information-centric material is not adequately addressed. Similarly, Business schools, while covering many important aspects of information management, rarely provide sufficient technical depth in this area.

We observe that a formalization of the basic principles is lacking in the information discipline although information related courses are being created at a rapid rate. This lack of formalization contributes to unstructured and “scatter gun” approaches to information technology education. The current situation calls for fundamental research, leading to a comprehensive curriculum for learning about information that is applicable for all age levels, ranging from K-12, community college, university, teacher training and professional development, workforce (re)training and entrepreneurship. In short, we must not limit ourselves by addressing only the current workforce. We need to focus on people as young as kindergarten (probably even younger) and on up through all the years of life (K-LL).

The Science Perspective

The first and most important task in designing an information-centric program is to define the fundamental science that serves as the core of each discipline. This science component is currently lodged in atomic quantities in the individual information disciplines and needs to be collated and synthesized to derive the core modules. For example, in the domain of information theory in electrical engineering, Shannon’s coding theory is a fundamental concept that helps quantify the redundancy and therefore the “true information” at the signal/bit level. The relevance and applicability of this theory for non-quantitative domains of information is at best minimal. Therefore, the fundamental science concept that unifies the various facets of these seemingly disparate components is crucial. Such a unified science component is a fundamental requirement for the development of a structured organization of information related concepts.

The authors have been working on the development of a preliminary science framework for “Information Disciplines” for a number of years (Golshani et al. 2000). Our efforts have been motivated primarily by drawing comparisons between information science and other disciplines, such as computer science. We believe that the information science concepts are lodged in various information centric disciplines and that the students get exposed to only one or more facets based on their chosen discipline. For example, the focus of an engineering major would be aspects of information coding theory, signal processing, systems theory, automata theory, logic, databases, etc. while that of a MIS major would be aspects of operations research, accounting, database theory, etc. Although these serve as starting points, the magnitude and scale of the overall science framework is much larger.
We can illustrate the entire spectrum of information processing (in its broadest sense) in the form of multiple paths, all leading to perceptible and useful information units, as presented in Figure 1. It is therefore timely to view information as an end product and look at its creation/generation process. There are clearly many processes for manipulation and management of information and, as yet, there is no discipline that studies these processes collectively.

Information representation, regardless of the medium through which it is conveyed, begins with the notion of “bits”. Designation of these bits would determine their subsequent treatment. In Figure 1, each of the vertical paths represents a medium of information abstraction and communication, namely audio, text, images, animation, alpha-numeric data and mathematical theories. Starting with the atomic objects at the bottom layer, each subsequent layer represents a more complex object. Note that every single notion included in Figure 1 deals with an aspect of information at a certain level of abstraction. Figure 2 illustrates the specific topics and their dependency on the information science core.

Figure 1. Information Types

A variety of perspectives at different layers (horizontally) and across different media types (vertically) may be identified.

Figure 2: Information Science Topics and Dependencies

The Overall Model

Our objective has been to put in place an all-encompassing curriculum based on a comprehensive “Information Science” core. By focusing on the science core, we can treat information-related disciplines as an integral part of a science curriculum. For example, in the K-12 domain, this has the advantage of allowing instruction to focus on what is really important: information. This is in contrast to current curricula, which tend to focus on technology and computers. By providing an underlying information
Our first implementation is a BS degree in Information Systems. With the aid of a grant from NSF, the program will have a specific track for teacher training in the area of information education. This is an information-centered curriculum for kindergarten through sixth grade, and includes a mobile road show and Internet-accessible modules in support of IT awareness. The modules, emphasizing a constructivist approach, are a direct product of applying information-centric concepts to education. The program focuses on making IT understandable and interesting at the elementary grade levels.

Program 2: IT Career Awareness: This is an information-centered curriculum for grades 6-12 and includes IT career shows to be hosted at ASU, Mesa Community College (MCC) and the local industries. The objectives are to relate information-centered educational exercises to activities in the world beyond high school. This approach lends itself naturally to the use of graphics and virtual reality features, which can transcend many of the barriers normally encountered by students whose native language is not English. Special attention is given to disadvantaged groups in society, such as inner city school children, rural schools and the Native American schools.

Program 3: IT Associate Degree: An information-centered curriculum leading to an IT Associate degree to be provided by Maricopa County Community College District (MCCCD). This is the largest community college system in the nation. The objectives are to broaden the scope of traditional IT programs, which often focus on vocational training.

Program 4: BS Degree: Our first implementation is a BS degree in Information Systems. With the aid of a grant from NSF, the authors are currently developing the basic science core for all information disciplines. One of the authors was part of the national task force whose work resulted in the development of Information Systems Engineering Curriculum '99 (ISCC'99).

Program 5: MS Degree and PhD: Graduate programs in Information Systems leading to MS and PhD degrees. The master’s degree program will have a specific track for teacher training in the area of information education.

Program 6: Teacher Preparation Programs: A teacher professional development program, for a variety of teachers with respect to the grade they teach and the subject they cover. This will include teachers of K-6 students, grade 7-12 students, Community College students, undergraduates, graduates and life-span learning students. The objective is to integrate the education curriculum with information science in a way that makes the use of computers and technology an incidental by-product. Computers become tools that facilitate the teaching of information science.

Program 7: Life-Span Learning: An information-centered curriculum for life-span learning, leading to career development and reorientation certificate degrees for managers, entrepreneurs, professionals and laborers. This program will provide prospective and current workers and managers with concepts related to the management of information in the corporate and entrepreneurial contexts. The focus on an information science core will facilitate integrating these courses into a comprehensive curriculum that can evolve over time as technology changes.

A concentration track on Information Systems would involve a total of five courses that will constitute the required upper division component. These courses essentially build upon the basic information science core. They are: Information Processing, Information-based Applications, Information-based Commerce, Information Practice Concepts I, and Information Practice Concepts II. The flow diagram for the required courses is shown in Figure 4, and the details of each course are presented below.
The success of the new program relies heavily on the following.

- Close collaboration with business and industry, particularly in definition of requirements and profile of graduates.
- Having a clear perspective, at both information concepts and information systems levels.
- Pedagogical aspects such as teaming, collaborative hands-on projects, and just-in-time learning.
- Integration of problem solving techniques, practical experiences, and meaningful case studies.
- Development of interpersonal skills should be actively promoted.
- Engineering and Business related issues are built into the courses.

Related to the above are the entrepreneurship activities, often neglected by information centric programs.

**Information Science**

**Objectives:** Train computer science students to develop a clear understanding of formal foundations of information engineering with the objective of becoming effective information specialists capable of dealing with all aspects of information handling.

**Course Outline:** Major topics covered in this course include: Information Types (alphanumeric, multimedia, continuous, multisensory, etc.); Engineering principles, conservation theory, information entropy; Overview of Shannon’s coding theory, its relevance and implications; Foundations of information science, reversible automata, conservative logic; Information Life Cycle: acquisition and generation, protection, marketing, sharing, presentation, communication, analysis and integration, management, discard; Mathematical principles of information processing, compression, and security.

**Information Processing**

**Objective:** This course expands on the basic concepts taught in the core course to encompass all aspects of information processing and processors. This course will prepare the students to embark on the design concentration of the capstone courses.

**Course Outline:** Review of the fundamentals of information processing, information creation, acquisition, sampling, quantization, and synchronization; Information filtering, transformation, and analysis; Information storage, compression and coding techniques; compression standards; Information processors, information networks, issues of transmission over narrowband, broadband and wireless networks; Information abstraction, indexing, browsing, and retrieval; Information protection, watermarking, security, and cryptography.

**Information Based Applications**

**Objective:** Students will learn how to analyze existing information systems to articulate the physical and logical structure as well as identify strengths and weaknesses in terms of functionality, system components, cost and performance.

**Course Outline:** Overview of information application domains, Characterization and classification of information applications; Establishing the criteria to compare the individual designs and relative performance evaluation; Justify and assess costs and benefits associated with system components and configurations across application domains; Team projects for application prototype building; Analysis and performance evaluation; Class discussions and projects.
**Information-Based Commerce**

**Objective:** The purpose of the course is to enable the students to understand the important issues related to the practice of information-based commerce including security, end-to-end transaction management, information kiosks, ethical and legal issues. It will also help students understand other important components such as information policy, intellectual property, and international

**Course Outline:** Planning and management of information; Data Protection and Information Security; Cryptography, Electronic Information and legislation; User-interface Designs; Health and Safety: relating to electronic displays, wireless devices, etc.; Copyright and protection of Intellectual property; Standards; Information Policy and Regulation; Economic, Social and Political issues, Information Society and Globalization; Entrepreneurship Issues.

**Capstone I - Information Practice Concepts I & II**

**Objective:** The objective is to expose the students to problems associated with large scale information systems problem solving, and engage them in real-world projects in the domain of information systems. Emphasis on case studies for understanding the design alternatives and trade-offs.

**Course Outline:** Fundamentals of system design; Overview of information content, resources, management, processing and communication; Quality, Standards and Performance measurement issues; Methods and basic structures to design efficient information systems; Information system life-cycle; Benefits of structured system analysis and design methodologies; Case Studies; Standards and Specifications to be followed in the design of information systems; Design specification of an information product; Implementation of the product, testing and evaluation; Interaction with the industry mentor and the team including attending weekly design meetings of the industry group.

Launching the proposed concentration track requires development and offering of the above five courses in a systematic manner. [Golshani, et al, 2001]

**Conclusions**

We have attempted to provide a completely new and innovative understanding of information and information technology that promises to establish new boundaries among the disciplines that are currently a part of the academic program. This project addresses research issues in fundamental information science, delivery methods, curriculum definition and workforce development for information topics at all age levels.

As an example, we present a comprehensive framework that leads to the creation of a coherent undergraduate curriculum in the area of Information Systems. Synergistically with this curriculum, we are implementing a series of programs for the entire community of people involved in information-related activities, each catering to a particular age group. As such our programs respond to educational needs by training students at all levels. Whereas in future we expect to see Information related programs offered routinely at different universities, we feel that a concentration track would be a suitable interim plan for many institutions interested in IT education (Denning, 2000).

**References**


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http://www.acm.org/ubiquity/interviews/p_denning_1.html

