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The Information Technology Model Curriculum

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Keywords: Information Technology, IT, curriculum, information systems, IS, computer science, CS

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The Information Technology Model Curriculum

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Abstract

The last twenty years has seen the development of demand for a new type of computing professional, which has resulted in the emergence of the academic discipline of Information Technology (IT). Numerous colleges and universities across the country and abroad have responded by developing programs without the advantage of an existing model for guidance. Efforts to define a model curriculum for IT began at the first Conference on Information Technology curriculum (CITC-1) in December 2001, which included representatives from 15 IT programs at four-year universities across the United States. Membership in SIGITE (Special Interest Group Information Technology Education) has grown to over 300 representing most of the four-year IT programs in the United States and abroad and many of the two-year IT programs in the United States. Continued development of the curriculum and subsequent funding by the Education Board of ACM enabled the completion of a first draft of the model curriculum for IT establishing program outcomes and a body of knowledge defining the discipline. This paper presents an overview of the results of that process.

Keywords: Information Technology, curriculum, information systems, computer science

1. BACKGROUND

At the first Conference on Information Technology Curriculum in December of 2001 representatives from 15 colleges/universities came together at Provo, Utah, to establish a national organization of IT educators and begin to establish academic standards for this rapidly emerging discipline. Several months earlier a steering committee composed of five of these universities compiled a

list of IT programs across the country to insure there was broad based participation of existing programs to provide input to the establishment of the society and the definition of the discipline.

In addition to the establishment of the Society for Information Technology Education (SITE), which later affiliated with ACM as SIGITE, committees were formed to work on the development of accreditation standards and a model curriculum for IT. Work continued on the model curriculum at CITC-2 (April 2002), CITC-3 (September 2002), CITC-4 (October 2003), and on a continuing basis by the curriculum committee. In October of 2004 funding was obtained from the Education Board of ACM to support completion of the model curriculum effort.

The intent of this paper is to summarize the progress that SIGITE has made towards formulating an IT model curriculum. The authors of this paper were responsible for writing the model curriculum, although their efforts were informed and augmented by a wider group of some 30 IT educators from approximately 15 different IT programs. The paper presents the process that was followed to arrive at the IT model curriculum in greater detail and describes the resulting IT model curriculum.

Use of the terms computer science and information systems in this paper refer to the disciplines described in the Computing Curricula 2005 Overview Report available for public comment at http://campus.acm.org /public/comments/Draft_5-23-05.pdf.

2. PROCESS

The IT model curriculum committee early established a number of principles that it would use in formulating its curriculum recommendation. The most significant of these were:

1. The formulation of the curriculum was governed by the desire to provide a blueprint to create programs that can be accredited.
2. Since the model curriculum was intended to exist as part of the CC2004 series, the committee followed the format developed in other documents within this series, in particular CC2001 – Computer Science, and adopted the terminology in that document to describe the IT body of knowledge.
3. Despite the rapidly evolving nature of Information Technology, the curriculum should have some longevity.
4. The curriculum should be flexible and the required body of knowledge must be as small as possible.
5. The curriculum must reflect those aspects that set Information Technology apart from other computing disciplines.
6. The curriculum must reflect the relationship of Information Technology to other computing disciplines.

Principle 1 meant that the ABET CAC (Computing Accreditation Commission) accreditation criteria for programs in IT became an important input to the curriculum design process. The criteria require programs seeking accreditation to formulate program educational objectives, defined as "statements that describe the career and professional accomplishments that the program is preparing graduates to achieve", and program outcomes, defined as "statements that describe what students are expected to know and be able to do by the time of graduation" (ABET CAC, 2004). In addition, a program is required to have a documented assessment process in place to determine the extent to which its graduates meet the program educational objectives and program outcomes. The results of this assessment process must then be used to improve the program. Many of the other accreditation criteria, such as those regarding faculty size, faculty qualifications, and institutional support, then ask institutions to show that the resources available to the program are sufficient to allow students to achieve the program educational objectives and program outcomes.

In order to give programs in specific computing disciplines (such as computer science, information systems, or information technology) further guidance, additional information is required. There has been a significant difference between computer science and information systems compared to information technology in how this additional guidance was provided. Computer science and information systems have given this additional guidance through the curriculum ac-

creditation criterion, in which they specified the topics that needed to be included in the program, and the number of credit hours that the program needed to offer in each of the topics. The IT community, in contrast, decided to give this additional guidance through the inclusion of minimal program outcomes in its IT specific accreditation criteria. In this regard, IT followed the general trend in accreditation. The advantages of using minimal program outcomes, rather than curricular guidelines, are numerous and include an encouragement of program innovation and experimentation. Moreover, program outcomes are preferable to curricular guidelines when it comes to communicating with potential employers about the skills and knowledge that they can expect graduates from particular programs to have, and are a much better vehicle for potential employers to express what they are looking for in graduates from a program.

SIGITE started the process of formulating program educational objectives and program outcomes during its second meeting in April 2002. The process continued until July of 2003 when the IT Model Curriculum Committee developed a high-level definition of the discipline and used this definition to finalize program educational objectives and outcomes for programs in IT. The definition of the discipline that was adopted was "*IT, as an academic discipline, focuses on meeting the needs of users within an organizational and societal context through the* ***selection, creation, application, integration and administration*** *of computing technologies*" (Ekstrom, Gorka, Kamali, Lawson, Lunt, Miller and Reichgelt, 2005, p. 5). The committee used this definition to formulate the following program educational objectives and program outcomes:

The program educational objectives of an Information Technology program include the ability to:

1. Explain and apply appropriate information technologies and employ appropriate methodologies to help an individual or organization achieve its goals and objectives;
2. Manage the information technology resources of an individual or organization;
3. Anticipate the changing direction of information technology and evaluate and communicate the likely utility of new technologies to an individual or organization;
4. Understand and for some to contribute to the scientific, mathematical and theoretical foundations on which information technologies are built;
5. Live and work as a contributing, well-rounded member of society.

To enable IT graduates to achieve the above program educational objectives they must possess the following skills upon graduation, namely the ability to:

(a) Use and apply current technical concepts and practices in the core information technologies;

(b) Analyze, identify and define the requirements that must be satisfied to address problems or opportunities faced by organizations or individuals;

(c) Design effective and usable IT-based solutions and integrate them into the user environment;

(d) Assist in the creation of an effective project plan;

(e) Identify and evaluate current and emerging technologies and assess their applicability to address the users' needs;

(f) Analyze the impact of technology on individuals, organizations and society, including ethical, legal and policy issues;

(g) Demonstrate an understanding of best practices and standards and their application;

(h) Demonstrate independent critical thinking and problem solving skills;

(i) Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation;

(j) Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology;

(k) Recognize the need for continued learning throughout their career.

Both the program educational objectives and program outcomes have been thoroughly reviewed by over 40 universities with IT programs and several industrial advisory boards at those institutions.

A second important input into the curriculum design process was a Delphi study conducted with participants at CITC-1 to identify curricular topics in an IT curriculum. Each participant was given a pad of self-adhesive sticky notes and a felt-tip marker; they were given twenty minutes to generate as many topics as possible. They were instructed to write one topic per sticky note. At the end of that session over 700 notes had been generated. Participants then organized the topics into groups with the freedom to relocate any of the topics. After approximately 30 minutes there was general agreement on the grouping of topics.

After the results of the "sticky note" exercise were compiled, 34 groupings were identified. Upon further review some of the topics were combined as they were closely related subsets of other topics. The results were disseminated to the participants for review and additional input was incorporated (Lunt, Ekstrom, Lawson, Reichgelt, Kamali, Miller and Gorka, 2004). This process formed the basis to identify the components of the body of knowledge.

The program outcomes were then applied to the results of the Delphi study to validate the suggested topics to include in an IT curriculum. Similar to the structure of the Computer Science (CS) model curriculum volume, CC2001, this process was used to develop the relevant knowledge areas for IT. The knowledge areas were then broken down further into units, which are defined in terms of individual topics and learning outcomes, indicating the level to which a student must become familiar with a particular topic.

Although the committee wanted the core of the curriculum to be as small as possible, it also wanted to give institutions guidance about how to set up an IT program. Therefore, the decision was made to supplement the core with elective material. However, rather than distinguish between core and elective knowledge units, as computer science had done in its 2001 model curriculum, the committee opted for an alternative way to specify elective material. There are a large number of careers that graduates from IT programs enter. Those careers show an enormous diversity and the knowledge base and skill sets required for each consequently vary widely as well. The curriculum was therefore designed in a way that gives an institution considerable freedom in tailoring the curriculum to the needs of its students and other institutional stakeholders. The committee recommended core outcomes that must be met, and provided example elective learning outcomes for additional depth in each unit of each knowledge area. Core learning outcomes describe skills for which there is a broad consensus that anyone obtaining a baccalaureate degree in the field must acquire them. The model curriculum also specifies a set of elective learning outcomes, typically skills that must be acquired by students specializing in the knowledge area with which that unit is associated. While the core and elective outcomes associated with a knowledge unit typically cover the same topics, the depth to which the topic is covered and the skill levels that students are expected to achieve differ significantly between core and elective learning outcomes.

3. RESULTS

The IT model curriculum contains the following knowledge areas:

- Information Technology Fundamentals
- Human Computer Interaction
- Information Assurance and Security
- Information Management
- Integrative Programming & Technologies
- Networking
- Programming Fundamentals
- Platform Technologies
- Systems Administration and Maintenance
- System Integration & Architecture
- Social and Professional Issues
- Web Systems and Technologies

The rationale for the inclusion of many of these modules follows directly from the definition of Information Technology as focusing on meeting the needs of users within an organizational and societal context through the

selection, creation, application, integration and administration of computing technologies. In order to be able to do so, an IT graduate must develop a myriad of skills.

First, every IT graduate must develop knowledge of the hardware and networking. This is covered in the knowledge areas Networking (NET) and Platform Technologies (PT). NET covers data communications, telecommunications, inter/intranetworking, infrastructure and an introduction to security. It also includes application of networking to multimedia, information storage and distribution, and the World Wide Web. PT covers the fundamentals of hardware and software and how they integrate to form essential components of IT systems.

Second, as any computing professional, the IT graduate must develop the skill to program, and there are two knowledge areas that cover this, namely Programming Fundamentals (PF) and Integrative Programming and Technologies (IPT). PF is very similar to programming courses or knowledge areas in the other computing model curricula. It develops skills and concepts that are essential to good programming practice and problem solving, and covers fundamental programming concepts, event-driven programming, object-oriented programming, basic data structures, and algorithmic processes. In contrast IPT is unique to the IT model curriculum and reflects the fact that the IT professional is more likely to be asked to integrate existing components, rather than develop new components. This knowledge area helps students develop the skills to do so and examines the various types of programming languages and their appropriate use, and the use of scripting languages, architectures, application programming interfaces and programming practices to facilitate the management, integration and security of the systems that support an organization.

Third, an important task of many IT professionals is to design, select, apply, and deploy computing systems and integrate them into the organization. They must also be able to administer and maintain these systems. This set of skills is developed in the System Integration and Architecture (SIA) and System Administration and Maintenance (SA) knowledge areas. SIA develops the skills to gather requirements, source, evaluate and integrate components into a single system, and validate the system. It also covers the fundamentals of project management and the interplay between IT applications and organizational processes. SAM covers the skills and concepts that are essential to the administration of operating systems, networks, software, file systems, file servers, web systems, database systems, and system documentation, policies, and procedures. It also includes education and support of the users of these systems.

Fourth, IT professionals focus on meeting the needs of users. It is therefore important that they develop the skill to determine user needs. Although aspects of this are covered in SIA, and indeed throughout the curriculum, the user is the primary focus of Human Computer Interaction (HCI). HCI is designed to help graduates develop a mind-set that recognizes the importance of users and organizational contexts and to learn to employ user-centered methodologies in the development, evaluation, and deployment of IT applications and systems. It covers such areas as user and task analysis, human factors, ergonomics, accessibility standards, and cognitive psychology. However, in order to adequately meet the needs of users, IT professionals must also develop an awareness of the social and professional context of information technology and computing, and adhere to ethical codes of conduct. The Social and Professional Issues (SP) knowledge area allows them to do so. It covers the historical, social, professional, ethical, and legal aspects of computing. It also identifies how teamwork is integrated throughout IT and how IT supports an organization. Finally, it stresses professional oral and written communication skills.

Fifth, IT graduates must develop technical skills to develop and maintain modern IT applications. Since most of these use some underlying database and/or are web-based, IT graduates must develop skills related to the management of information and web technologies. These skills are covered in the Information Management (IM) and Web Systems and Technologies (WS) knowledge areas respectively.

The final set of skills that IT professionals have to develop relate to security. IT systems are increasingly under attack. The IT

professional must understand, apply, and manage information assurance and security in computing, communication, and organizational systems. The Information Assurance and Security (IAS) knowledge area is designed to allow them to develop these skills. It also instructs students how to provide users with a framework to be sufficiently security aware in order to be an asset to the organization rather than a liability. IAS includes operational issues, policies and procedures, attacks and defense mechanisms, risk analyses, recovery, and information security.

While the different knowledge areas are to some extent independent, the model curriculum identifies a set of themes that pervade the curriculum, as they define the essence of IT as an academic discipline. Although IT will share some of these pervasive themes with the other computing disciplines, their combination is unique to IT and sets IT apart from the other computing disciplines. The pervasive themes are:

- User centeredness and advocacy
- Information assurance and security
- The ability to manage complexity through: abstraction & modeling, best practices, patterns, standards, and the use of appropriate tools
- A deep understanding of information and communication technologies and their associated tools
- Adaptability
- Professionalism (life-long learning, professional development, ethics, responsibility)
- Interpersonal skills

These pervasive themes are expected to recur throughout the curriculum. However, the model curriculum also proposes that they are explicitly introduced in a first IT course that majors are exposed to. This course is intended to cover the IT Fundamentals (ITF) knowledge area. This knowledge area provides an overview of the discipline of IT, describes how it relates to other computing disciplines, and begins to instill an IT mindset. The goal is to help students understand the diverse contexts in which IT is used and the challenges inherent in the diffusion of innovative technology.

4. CONCLUSION

The committee has progressed from the very fundamental stages of IT content/outcome development, to a more clearly defined set of program educational objectives, outcomes, and knowledge areas, and has been able to formulate a first draft of a model curriculum for IT. Our hope is that readers will carefully review this first draft and be willing to offer candid, constructive feedback to further the goal of developing a fundamentally strong, diversified, outcome driven curriculum for IT.

The committee recognizes the dynamic nature of computing and specifically the IT environment and recommends that there be an ongoing review process that allows individual components of the curriculum recommendations to be updated on a recurring basis. The IT model curriculum volume is publicly available for comment at http://sigite.acm.org/activities/curriculum/ and comments can be sent to the chair of the SIGITE curriculum committee, Barry Lunt, at luntb@byu.edu.

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