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IT2008: Information Technology Model Curriculum

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ABSTRACT

IT2008 is the official result of a seven-year effort to understand and codify the content and structure of accreditable four-year information technology programs. The process began with a meeting and Delphi exercise in October 2001 and culminated with a final push in 2008. The final document combines efforts of many people and represents an excellent starting point for anyone wishing to unterstand information technology as an academic discipline.

This paper presents a brief background to provide overall context, an overview of the stucture and content of IT2008, and some observations on the unique features of the document. IT2008 is the latest volume of the IEEE-CS/ACM joint taskforce on coumputing curricula's Computing Curriculum series which consists of an overview document (CC2005) and model curricula for Computer Science (CC2001), Computer Engineering (CE2004), Information Systems (IS2002), Software Engineering (SE2004), and Information Technology (IT2008).

Keywords: Accreditation, Curriculum, Computing, Information Technology

1. BACKGROUND

In the early to mid 1990s a few institutions began to recognize that there were needs to educate technical professionals specializing in networking, the web, and related topics. These system-delivery oriented skill sets did not match the algorithmic/programming-oriented Computer Science programs that were available. The skill requirements were more technical than the business-oriented IS programs. Programs emerged that were called everything from Information Systems to Computer Science but were neither if analyzed from the content of their courses. They were something else: computing-oriented programs with a focus on the delivery and management of the emerging networking based distributed computing environments upon which web applications depend. By 2000 there were at least 17 programs that had or were forming programs with similar characteristics.

In December 2001 the first Conference on Information Technology Education was held (CITC-1). From the beginning of the meetings, it was clear that there was a core vision of IT as an emerging discipline. The Society for Information Technology Education was established. Committees were created to formulate accreditation criteria and a model curriculum; and a Delphi study was conducted to determine which topics the participants thought should be covered in an IT program (Lunt et al., 2004). Another conference was planned for the following April and the momentum continued through CITC-2 (April 2002), CITC-3 (September 2002), and CITC-4 (October 2003). SITE became an ACM Special Interest group in 2003 and there have been annual SIGITE conferences every October ever since.

The curriculum committee formed at CITC-1 did some preliminary work further refining the results of the Delphi Study. In 2003 a writing committee was formed consisting of seven people who took the responsibility to

produce the document. By this time, it had been decided that IT would be accredited though Computing Accreditation Commission, CAC of ABET, and that the document produced should be written as the IT volume for the work being done by the IEEE-CS/ACM joint committee on computing curriculum, which was working on the Overview Document alluded to in CC2001 and was published as CC2005. Two members of the writing committee participated in that process, and IT was recognized as one of the 5 sister disciplines of computing.

Over the next two years, the writing committee met every other month to work on the project as a team. In between these meetings there were phone conferences with the larger curriculum committee, and several full committee meetings were held to report progress and obtain feedback. In October of 2005, IT2005 was posted to the ACM web site as a draft for final review. Over the next year minor feedback was received and changes were incorporated into the draft. In January 2007, significant issues were raised by the ACM Education Board that required a major revision of the document. It became clear that certain aspects of the curriculum document were easily misunderstood by key segments of the target audience; this needed to be fixed.

In October 2007 (Lunt et al., 2008) it was decided that representatives from the ACM and IEEE-CS should be directly involved in the process. A steering committee was formed consisting of two members of the SIGITE writing committee and one member each from both the ACM and IEEE-CS. Over the next several months, a major revision was made that incorporated the input from the new participants in the process. It was an important exercise in writing that produced a document which was much less likely to be misunderstood.

2. STRUCTURE OF THE DOCUMENT

IT2008 is modeled on the CS2001 volume. It has twelve chapters that describe the contents, process, and overall organization of the IT body of knowledge, along with three Appendices. Appendix A is the detailed description of the BOK associated learning outcomes. Appendix B provides Course Descriptions. It was decided that to be most useful, detailed course implementations and strategies for developing individual courses should be provided. And Appendix C is a locator matrix for outcomes in the Knowledge Areas.

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3. SUMMARY OF THE DOCUMENT

A good summary of IT2008 is found in the Executive Summary. An excerpt is included here:

- *The IT body of knowledge*. We have identified a body of knowledge appropriate to four-year Information Technology programs. Drawing on the structure of earlier curriculum reports (most notably the CS2001 volume), we have arranged that body of knowledge hierarchically by subdividing the field into knowledge areas which are then broken down further into units. These units are defined in terms of individual topics and learning outcomes. An overview of the body of knowledge appears in Chapter 5.

- *Learning outcomes*. For each unit in the body of knowledge, we have developed a set of learning outcomes. These learning outcomes appear as part of the detailed description of the body of knowledge in Appendix A. For most units, the learning outcomes are divided into core outcomes and advanced outcomes. In addition to the individual learning outcomes, the report outlines a set of characteristics that all Information Technology graduates should possess in Chapter 10.

- *The IT core*. From the 85 units in the body of knowledge, we have selected 81 that contain the core material, accounting for approximately 314 hours of instruction. As noted in our statement of principles in Chapter 4, we defined the core as the set of learning outcomes for which there is a broad consensus that the material is essential to a four-year degree in Information Technology. The philosophy behind the definition of the core is described in more detail in Chapter 5.

- *The IT Advanced Outcomes*. The core is not a complete curriculum, and must be supplemented by additional material. This document proposes IT advanced learning outcomes that may be used to complete a curriculum. These advanced learning outcomes are usually part of units that also contain core learning outcomes, although there are some units that only have advanced outcomes defined.

- *Curriculum models*. The report identifies two approaches to undergraduate instruction in Information Technology, as described in Chapter 6. Building on that foundation, Chapter 7 describes the core material of the Information Technology curriculum, and Chapter 8 describes the additional material necessary to constitute a complete four-year curriculum in Information Technology.

- *Course descriptions*. Appendix B contains a detailed model of two curricular approaches, including course descriptions for 33 courses (IT2008 Executive Summary).

4. CONTENTS OF THE DOCUMENT

The first four chapters of IT2008 are introductory material that provide background and motivation information to set the stage for the curriculum presentation. Chapter 1 provides general information, particularly the definition of IT from the academic perspective.

> *Information Technology (IT) in its broadest sense encompasses all aspects of computing technology. IT, as an academic discipline, is concerned with issues related to* ***advocating for users*** *and meeting their needs within an organizational and societal context through*

*the **selection, creation, application, integration and administration** of computing technologies* (IT2008 Section 1.3).

Closely related to the definition of the discipline that was agreed upon early in the process are the broad goals that emerged from the thinking about accreditation objectives—the expectations of student abilities five years after graduation.

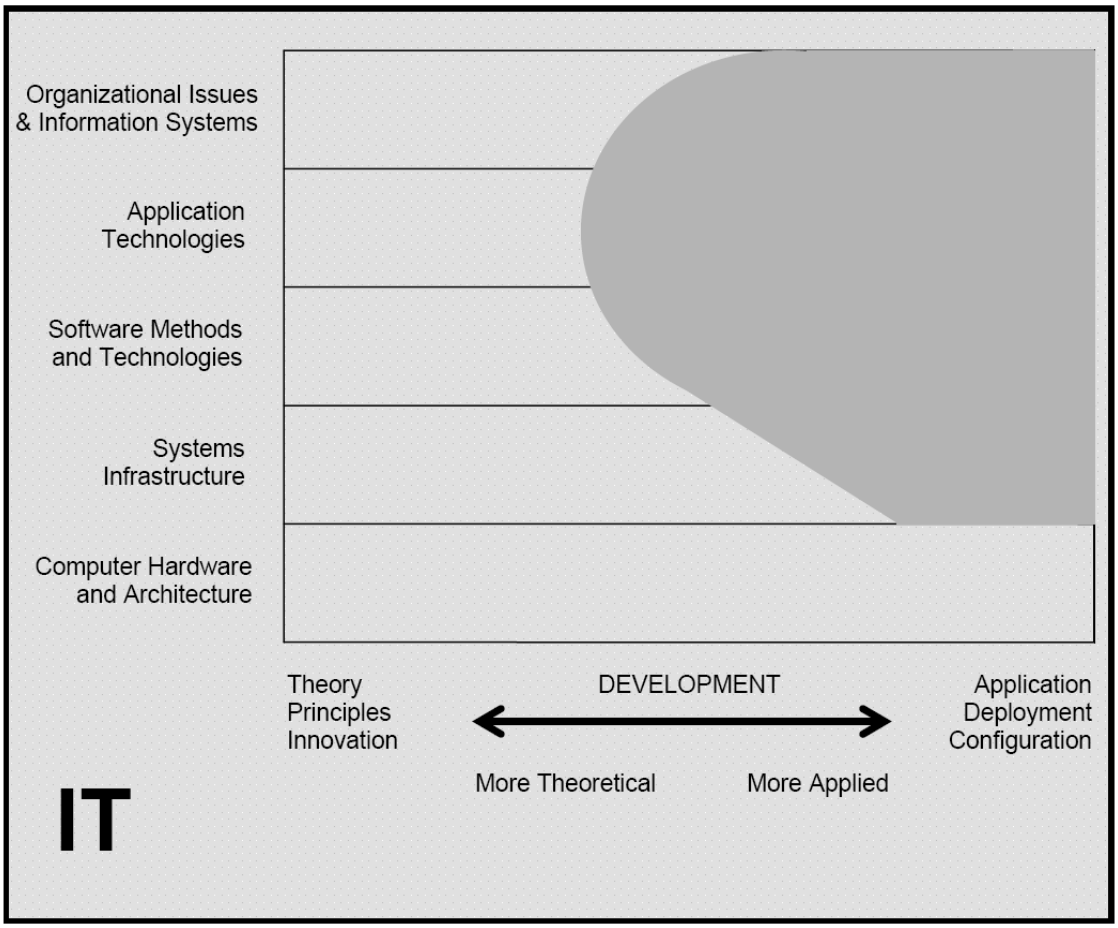
1. Explain and apply appropriate information technologies and employ appropriate methodologies to help an individual or organization achieve its goals and objectives;
2. Function as a user advocate;
3. Manage the information technology resources of an individual or organization;
4. Anticipate the changing direction of information technology and evaluate and communicate the likely utility of new technologies to an individual or organization;
5. Understand and, in some cases, contribute to the scientific, mathematical and theoretical foundations on which information technologies are built;
6. Live and work as a contributing, well-rounded member of society.
(IT2008 Section 1.4).

The characteristics of an IT graduate at graduation are similar to the list in many ABET accredited disciplines "a-n" for IT are introduced in Section 3.3 of the model curriculum document and copied directly from the IT Accreditation document.

a) An ability to apply knowledge of computing and mathematics appropriate to the discipline
b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
d) An ability to function effectively on teams to accomplish a common goal
e) An understanding of professional, ethical, legal, security and social issues and responsibilities
f) An ability to communicate effectively with a range of audiences
g) An ability to analyze the local and global impact of computing on individuals, organizations, and society
h) Recognition of the need for and an ability to engage in continuing professional development
i) An ability to use current techniques, skills, and tools necessary for computing practice.
j) An ability to use and apply current technical concepts and practices in the core information technologies.
k) An ability to identify and analyze user needs and take them into account in the selection, creation, evaluation and administration of computer-based systems.
l) An ability to effectively integrate IT-based solutions into the user environment.
m) An understanding of best practices and standards and their application.
n) An ability to assist in the creation of an effective project plan.

Chapter 3 also provides information about the relationship between IT and its sister disciplines. CC2005 uses a set of charts that position the five computing disciplines in a space that provides a way to visualize the focus of the curricula based upon their outcomes. As can be seen from the figure below, IT is focused on the practical aspects of computing, application, deployment,

and configuration, as well as the practical aspects of systems, software, technologies, and organizations.



(IT2008 Figure 3.1)

From the beginning of the process started at CITC-1, we referred to the "Pillars of IT" as programming, networking, HCI, databases, and web systems. Though some of us would like to change the "web systems" to the more general "distributed systems", the basic model has remained constant. The picture below captures the general model in a graphic form:

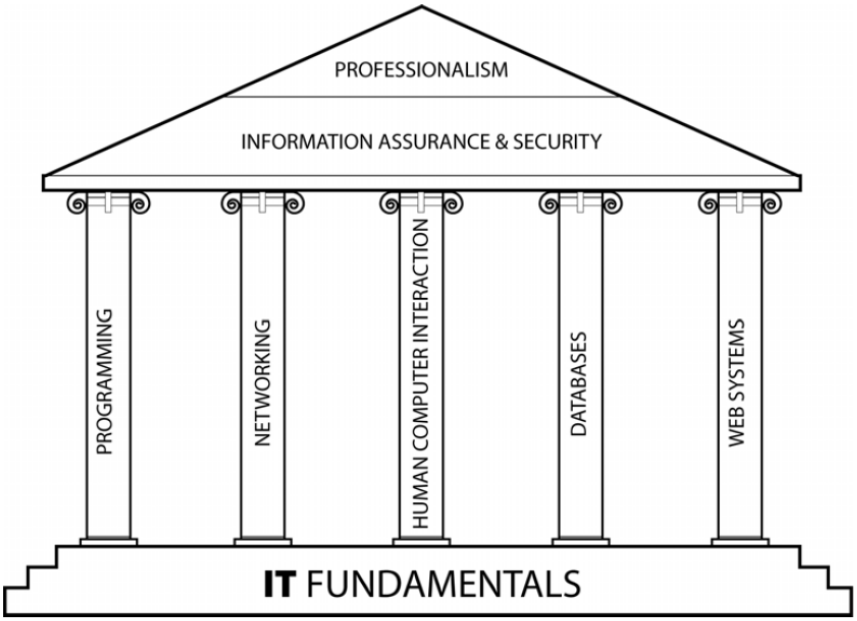


Figure 3-2. The Information Technology Discipline

(IT2008 Figure 3-2)

The principles enumerated in Chapter 4 guided the construction of the model curriculum, and should be of particular interest to those seeking understanding of the thinking behind its creation. These principles were decided upon in 2003 and remained constant through the entire process.

1. *Although this document can in principle be used as a stand-alone document, the formulation of the curriculum was governed by the desire to provide a blueprint to create accreditable programs.*
2. *This document is intended to exist as part of the CC2005 series*
3. *Despite the rapidly evolving nature of information technology, we wanted to formulate a curriculum with some longevity.*
4. *The curriculum must 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.*
7. *This document is aimed at four-year programs offered at U.S. institutions of higher learning, but should also be applicable in other contexts.*
8. *The development of this volume must be broadly based.*
9. *This volume must go beyond knowledge areas to offer significant guidance in terms of implementation of the curriculum.* [IT2008 Chapter 4]

Chapter 5 introduces the IT Body of Knowledge (BOK). The one-page summary is included at end of this document. During the process of organizing the BOK, we found that being able to view this short form allowed us to keep track of the forest without getting lost in the trees.

The Information Technology Body of Knowledge

ITF. Information Technology Fundamentals (25 core hours)
- ITF. Pervasive Themes in IT (17)
- ITF. History of Information Technology (3)
- ITF. IT and Its Related and Informing Disciplines (3)
- ITF. Application Domains (2)

HCI. Human Computer Interaction (20 core hours)
- HCI. Human Factors (6)
- HCI. HCI Aspects of Application Domains (3)
- HCI. Human-Centered Evaluation (3)
- HCI. Developing Effective Interfaces (3)
- HCI. Accessibility (2)
- HCI. Emerging Technologies (2)
- HCI. Human-Centered Computing (1)

IAS. Information Assurance and Security (23 core hours)
- IAS. Fundamental Aspects (3)
- IAS. Security Mechanisms (Countermeasures) (5)
- IAS. Operational Issues (3)
- IAS. Policy (3)
- IAS. Attacks (2)
- IAS. Security Domains (2)
- IAS. Forensics (1)
- IAS. Information States (1)
- IAS. Security Services (1)
- IAS. Threat Analysis Model (1)
- IAS. Vulnerabilities (1)

IM. Information Management (34 core hours)
- IM. IM Concepts and Fundamentals (8)
- IM. Database Query Languages (9)
- IM. Data Organization Architecture (7)
- IM. Data Modeling (6)
- IM. Managing the Database Environment (3)
- IM. Special-Purpose Databases (1)

IPT. Integrative Programming & Technologies (23 core hrs)
- IPT. Intersystems Communications (5)
- IPT. Data Mapping and Exchange (4)
- IPT. Integrative Coding (4)
- IPT. Scripting Techniques (4)
- IPT. Software Security Practices (4)
- IPT. Miscellaneous Issues (1)
- IPT. Overview of Programming Languages (1)

MS. Math and Statistics for IT (38 core hours)
- MS. Basic Logic (10)
- MS. Discrete Probability (6)
- MS. Functions, Relations and Sets (6)
- MS. Hypothesis Testing (5)
- MS. Sampling and Descriptive Statistics (5)
- MS. Graphs and Trees (4)
- MS. Application of Math & Statistics to IT (2)

NET. Networking (22 core hours)
- NET. Foundations of Networking (3)
- NET. Routing and Switching (8)
- NET. Physical Layer (6)
- NET. Security (2)
- NET. Network Management (2)
- NET. Application Areas (1)

PF. Programming Fundamentals (38 core hours)
- PF. Fundamental Data Structures (10)
- PF. Fundamental Programming Constructs (10)
- PF. Object-Oriented Programming (9)
- PF. Algorithms and Problem-Solving (6)
- PF. Event-Driven Programming (3)

PT. Platform Technologies (14 core hours)
- PT. Operating Systems (10)
- PT. Architecture and Organization (3)
- PT. Computing Infrastructures (1)
- PT. Enterprise Deployment Software
- PT. Firmware
- PT. Hardware

SA. System Administration and Maintenance (11 core hours)
- SA. Operating Systems (4)
- SA. Applications (3)
- SA. Administrative Activities (2)
- SA. Administrative Domains (2)

SIA. System Integration and Architecture (21 core hours)
- SIA. Requirements (6)
- SIA. Acquisition and Sourcing (4)
- SIA. Integration and Deployment (3)
- SIA. Project Management (3)
- SIA. Testing and Quality Assurance (3)
- SIA. Organizational Context (1)
- SIA. Architecture (1)

SP. Social and Professional Issues (23 core hours)
- SP. Professional Communications (5)
- SP. Teamwork Concepts and Issues (5)
- SP. Social Context of Computing (3)
- SP. Intellectual Property (2)
- SP. Legal Issues in Computing (2)
- SP. Organizational Context (2)
- SP. Professional and Ethical Issues and Responsibilities (2)
- SP. History of Computing (1)
- SP. Privacy and Civil Liberties (1)

WS. Web Systems and Technologies (22 core hours)
- WS. Web Technologies (10)
- WS. Information Architecture (4)
- WS. Digital Media (3)
- WS. Web Development (3)
- WS. Vulnerabilities (2)
- WS. Social Software

Total Hours: 314

Notes:
1. Order of Knowledge Areas: Fundamentals first, then ordered Alphabetically.
2. Order of Units under each Knowledge Area: Fundamentals first (if Present), then ordered by number of core hours.

Chapters 5-8 describe the actual curriculum and provide additional guidance in understanding the more detailed information provided in the appendices.

Chapters 9-12 provide guidance as to how an IT program fits into the overall context of a college education and the structure of the educational institution.

5. OBSERVATIONS ON THE PROCESS

We owe a tremendous debt to the organizations and educators who have gone before. The guidance received members of the Joint Curriculum Committee at CITC-1 and frequently during the entire process made the effort much more effective. The CC2005 joint committee and the authors of the other model curriculum volumes led the way and provided the roadmap of how to create a model curriculum in computing. However, we also learned that there are often assumptions about an approach that are not obvious to an outside observer.

The division between core and advanced outcomes is the most significant difference between the IT volume and the other volumes of the series. It was also one of the major areas of misunderstanding. CC2001 distinguishes between "core" and "elective" knowledge units. Initially we attempted to follow that convention, but we found that most of the units contained outcomes that we believed every IT student should achieve, and also outcomes that pertained to students with an emphasis that included that area. Thus, we decided that we should distinguish between core and elective *outcomes* rather than core and elective *knowledge units.* This naming convention led to confusion as the IT2005 document was reviewed. As part of the review process for IT2008, the term *elective* was eliminated in favor of the term *advanced.* Thus the final version defines a set of core outcomes spread across all but one or two of the knowledge units, and a large set of advanced outcomes that are also included in the units. The core outcomes are those that all could agree *every* IT student should achieve. It should be emphasized that every student must also achieve a significant subset of the advanced outcomes based upon the emphasis chosen by the student and the flavor of the particular IT program.

The addition of representatives from IEEE-CS and ACM was the key that allowed us to recognize and correct areas of misunderstanding. The creation of a model curriculum requires going beyond the normal care required to write for understanding. It requires additional care and a different kind of independent review to write to avoid misunderstanding.

6. CONCLUSION

The 2008 version of the 4-Year IT Curriculum volume gives an excellent introduction to the academic discipline of information technology, along with recommendations for the content and delivery of an IT curriculum. This curriculum volume represents the best efforts of many individuals from many academic institutions and professional organizations. It increases to five the number of computing programs that have formally defined curricula, as outlined in the CC 2005 document. It has received wide exposure both nationally and internationally, and has already had a significant impact on many computing programs both in the USA and abroad. We hope it continues to serve a useful role throughout its lifetime.

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