

Integration of Information Assurance and Security into the IT2005 Model Curriculum

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Abstract – In December 2001 a meeting of interested parties from fifteen four-year IT programs from the US along with representatives from IEEE, ACM, and ABET (CITC-1) began work on the formalization of Information Technology as an accredited academic discipline. The effort has evolved into SIGITE, the ACM SIG for Information Technology Education. During this period three main efforts have proceeded in parallel: 1) Definition of accreditation standards for IT programs, 2) Creation of a model curriculum for four-year IT programs, and 3) Description of the characteristics that distinguish IT programs from the sister disciplines in computing.

During the deliberations of the SIGITE Curriculum Committee, several topics emerged that were considered essential, but that did not seem to belong in a single specific knowledge area or unit. One of the most significant of these “pervasive themes” is Information Assurance and Security (IAS). A consensus emerged that these themes must be addressed during the entire learning experience and that students and instructors need to be constantly aware of how these themes are woven through the fabric of the curriculum.

In this paper we present an introduction to SIGITE and the context of the work of the Curriculum Committee on IT2005, the IT curriculum volume described in the Overview Draft document of the Joint Task Force for Computing Curriculum 2004. We then describe the IAS component of the IT2005 document and how we are implementing it at BYU as a “pervasive theme” that is woven through the curriculum. We conclude with some observations about the first year’s experience.

The primary purposes of this paper are to introduce the IT2005 Volume of Computing Curriculum and to solicit feedback on the draft from the IA community.

Index terms – Information Technology, Education, Curriculum, Information Assurance, Security

I. INTRODUCTION AND CONTEXT

In the first week of December of 2001 representatives from 15 undergraduate information technology (IT) programs from colleges/universities across the country gathered together near Provo, Utah, to develop a community and begin to establish academic standards for this rapidly growing discipline. This first Conference on Information Technology Curriculum (CITC-1) was also

attended by representatives from two professional societies, the Association for Computing Machine (ACM) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE), and also the Accreditation Board for Engineering and Technology, Inc. (ABET). This invitational conference was the culmination of an effort begun several months earlier by five of these universities who had formed a steering committee to organize a response from existing IT programs to several initiatives to define the academic discipline of IT. The steering committee wanted to ensure that the input of existing programs played a significant role in the definition of the field.

A formal society and three main committees were formed by the attendees of CITC-1. The society was the Society for Information Technology Education (SITE); one of the committees formed was the executive board for SITE, composed of a president, vice-president, secretary, treasurer, regional representatives, and an activities chairperson. The other two committees formed were the IT Curriculum Committee, including subcommittees for 4-year and 2-year programs, and the IT Accreditation Committee, also including subcommittees for 4-year and 2-year programs.

The development of IT as an academic discipline is similar to the process that computer science (CS) went through in the 70's and 80's. In fact, looking at the placement of CS programs in academic institutions around the U.S. illustrates the debate that swirled around the discipline as its core was being defined. Some CS programs are in departments of mathematics, others are in engineering schools, and many others have become mainstay programs within newly emerging colleges of computing.

Information technology, as it is practiced at this moment in its evolution, reflects similar growing pains. IT programs exist in colleges of computing, in CS departments, in schools of technology, and in business schools. Professors of information technology possess degrees in information systems, electronics, communications, graphics arts, economics, mathematics, computer science, and other disciplines. Few to none of them have a degree in information technology.

It should be acknowledged here that IT has two substantially different interpretations, and that these should be clarified. Information Technology (IT) in its broadest sense encompasses all aspects of computing technology. 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. A more detailed history of SIGITE is available in [1].

SIGITE is directly involved with the Joint Task Force for Computing Curriculum 2004 and has 2 representatives on the task force. This task force is a continuation of the effort that created CC2001 [2] the current computer science curriculum standard. CC2001 has been relabeled CS2001 and the current draft of the CC2004 Overview document [3] presents the structure being used to describe computing and its sub-disciplines (See Figure 1). The SIGITE Curriculum Committee is responsible for IT2005, the Information Technology Curriculum Volume. IT2005 was made available for comment in mid 2005.

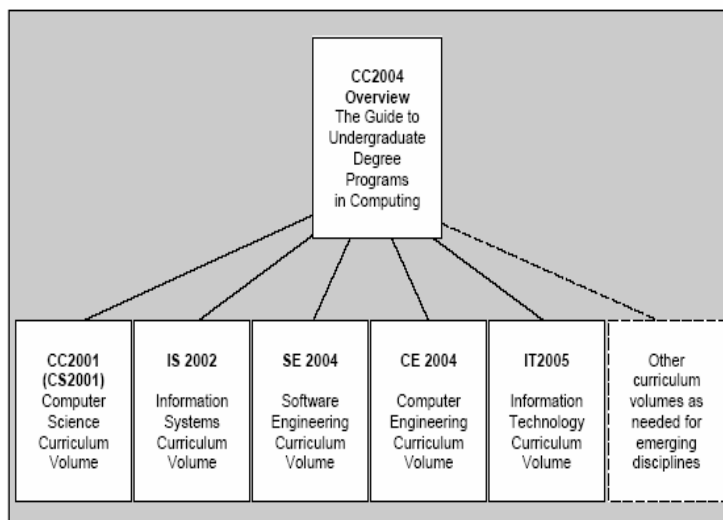


Figure 1

Now that the reader understands the history and context of IT2005, we will give a brief overview of the document and the model curriculum. Following that we will examine the Information Assurance and Security knowledge area (IAS) and the pervasive nature of the topics and learning outcomes it includes. We will conclude with a description of the approach we have been using at BYU to implement IAS as a pervasive theme throughout our 4 year IT curriculum and our initial results with the approach.

II. INFORMATION ASSURANCE IN IT2005

The IT2005 volume is modeled on CS2001. It consists of 12 chapters and 2 appendices. The current draft resides at <http://sigite.acm.org/activities/curriculum/>[4]

- Chapter 1. Introduction
- Chapter 2. Lessons from Past Reports
- Chapter 3. Changes in the Information Technology Discipline
- Chapter 4. Principles
- Chapter 5. Overview of the IT Body of Knowledge
- Chapter 6. Overview of the Curricular Models
- Chapter 7. The Core of the Curriculum
- Chapter 8. Completing the Curriculum
- Chapter 9. Professional Practice
- Chapter 10. Characteristics of IT Graduates
- Chapter 11. Computing across the Curriculum
- Chapter 12. Institutional Challenges
- Acknowledgements
- Bibliography
- Appendix A. The IT Body of Knowledge
- Appendix B. IT Course Descriptions

Chapters 5 and 7 are of particular interest for this discussion. Chapter 5 is an overview of the IT body of knowledge. A summary is included as Appendix A. Chapter 7 discusses the relationship of the core topics described in the body of knowledge to IT curriculum. IAS is explicitly mentioned in three contexts:

- Section 7.2 as part of the IT Fundamentals Knowledge Area (KA)
- Section 7.2 as a “pervasive theme”
- Section 7.4 as a KA that integrates the IAS concepts for students ready to graduate.

IAS is the only area that is an IT Fundamental, a “pervasive theme” and also a complete KA with a recommended senior level course for integrating all of the concepts. Clearly, IT2005 presents Information Assurance and Security as a core competency required by every graduate of an IT program.

During the early analysis of IT as an academic discipline, Delphi studies were performed that ranked “Security” as a central area for IT. [1] As we studied the issues several members of the committees involved were uncomfortable with “security” as the name for the knowledge area. The name seemed too restrictive. In late 2003 we discovered that NSA had begun to use the umbrella term Information Assurance [5] to cover what we were calling security. Even though this term is defined to cover exactly what the IT community meant by security, the use of the terminology elicited a lot of

blank stares. We found that explicitly adding security to the name of the knowledge area eliminated much of the confusion. We are indebted to the Center for Education and Research for Information Assurance and Security (CERIAS)[6] at Purdue whose name provided the inspiration to use IAS as a name for the knowledge area.

Once the naming issue was resolved, the SIGITE curriculum committee struggled to find a model for IAS that could

- be understood by a freshman
- provide a framework to integrate IAS concepts that are integrated into nearly all of the other KAs
- be rich enough to support a senior level course that ties everything together.

When *A Model for Information Assurance: An Integrative Approach* [7] was discovered the writing committee achieved consensus on a model. The cube (see Figure 2) provides a simple visual representation that a freshman can understand, yet the 3 dimensional structure facilitates the detailed analysis required for use in technology specific contexts.

Information Assurance Model

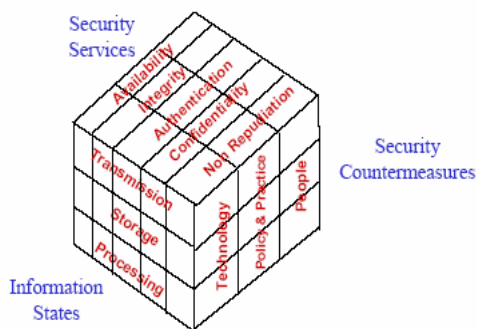


Figure 2

IT2005 uses this model to structure IAS concepts throughout the document.

III. RECOMMENDATIONS FOR “PERVASIVE THEMES” IN IT2005

During the deliberations of the SIGITE Curriculum Committee, several topics emerged that were considered essential, but that did not seem to belong in a single specific knowledge area or unit. These topics, referred to as pervasive themes, are:

- user advocacy
- information assurance and security
- ethics and professional responsibility

- 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
- life-long learning and professional development
- interpersonal skills

The committee states “that these topics are best addressed multiple times in multiple classes, beginning in the IT fundamentals class and woven like threads throughout the tapestry of the IT curriculum”[8].

These themes need to be made explicit in the minds of the students and the faculty. The themes touch many of the topics throughout the curriculum. Every time a new technology is announced in the media, an instructor has the opportunity to drive home the importance of “life-long learning”. Every time there is a cyber-crime in the media we have the opportunity to discuss the ethical and professional ramifications. It is recommended that an IT Fundamentals course be taught early in the curriculum where all of these themes are introduced and discussed as concepts that touch everything an IT professional does.

Each of these topics deserves a full treatment; however, for the purposes of this paper we will focus on IAS, possibly the most pervasive theme. We will address one approach to achieve addressing IAS “multiple times in multiple classes” in section VI below.

IV. THE INFORMATION ASSURANCE AND SECURITY KNOWLEDGE AREA

At the annual SIGITE conference in 2003 we (both authors) were introduced to the Center for Research and Education in Information Assurance and Security (Cerias) at Purdue. We were dissatisfied with the security component in our IT curriculum at BYU and were struggling with the Security KA in the SIGITE Curriculum committee. Through flyers at the conference we became aware of the Information Assurance Education Graduate Certificate (IAEGC) program funded by the NSA. With encouragement from colleagues and the administration of the School of Technology, the primary author attended the 2004 program. The experience has had a significant impact on IT2005 and the BYU curriculum.

In early 2003, the SIGITE curriculum committee divided into working groups around the knowledge areas defined by [1] to make an initial cut at the list of topics for each

KA. A significant revision was accomplished and reviewed by the participants at the 2004 IAEGC program at Purdue in August 2004. The list of areas for the IAS KA was finalized in late 2004 at a full IT Curriculum Committee meeting. The draft of the completed IAS KA was completed in early Feb 2005 by the IAS working group, edited by the writing committee in late Feb 2005 and was presented to the full committee in April 2005. From this brief history, it is clear that IT2005 is still a work in process. One of the primary purposes of this paper is to inform the IA community about the effort and solicit feedback.

<p>IAS. Information Assurance and Security (23 core hours) IAS1. Fundamental Aspects (3) IAS2. Security Mechanisms (countermeasures) (5) IAS3. Operational Issues (3) IAS4. Policy (3) IAS5. Attacks (2) IAS6. Security Domains (2) IAS7. Forensics (1) IAS8. Information States (1) IAS9. Security Services (1) IAS10. Threat Analysis Model (1) IAS11. Vulnerabilities (1)</p>
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Figure 3

Figure 3 is a list of the IAS KA and its areas. The basic structure and vocabulary is derived directly from Maconachy, et. al.[7]. The number in parenthesis is the number of lecture hours the committee thought would be required to give an IT student minimum exposure to the unit. It should be noted that the ordering of areas in all of the KAs, is first “Fundamentals”, if there is one, and then the areas are sorted in order of the number of core hours. This ordering should not be considered as any indication of the order the units would be covered pedagogically in an implemented curriculum.

A summary of the IAS KA is in Appendix A, and a complete treatment is found in IT2005 [4], including topics, core learning outcomes, and example elective learning outcomes.

In reviewing this model curriculum for IAS in Information Technology, it should be remembered that the core topics and associated lecture hours are the minimum coverage that *every IT student in every program should receive*. We would expect that most programs would provide significantly more instruction in Information Assurance and Security than is specified in IT2005 as a minimum.

V. IT AT BRIGHAM YOUNG UNIVERSITY

The Information Technology program at BYU began officially in Fall 2001 with a faculty consisting of:

1. Two Electronics Engineering Technology (EET) professors that were instrumental in the evolution of the existing EET program at BYU into an IT program,
2. One Electrical Engineering, Ph.D. newly arrived from the aerospace industry.
3. One computer scientist instructor who had done part time teaching and had been part of the department for 1 year with several years in system development in health care.
4. One computer science Ph.D. with recent executive management responsibilities in network hardware and service provider businesses.
5. The former department chair of the technology education program for secondary schools joined in 2002.
6. One computer science Ph. D. with extensive industry experience in data privacy and IT management joined in 2004.

This is very diverse group of people, each of whom joined the department because they thought that the existing computing programs at BYU did not offer students preparation for the practical aspects of system delivery to customers. We are evenly divided between long-term academics and recent retreats from industry. However, the academics have also each had significant industrial experience which provided the motivation for them to accept positions in the new IT program.

The BYU curriculum began as a traditional “stovepipe” approach of courses oriented around topics like networking, databases, and operating systems borrowed from CS, EET, CE and IS, and evolved to a more integrated approach starting at the introductory levels so that advanced topic oriented courses are more easily sequenced. We have also discovered that the integrative nature of IT forces a focus on the seams between technologies rather than implementation of components. This fundamental difference in focus is one of the primary differences that distinguishes IT from other computing disciplines that focus on the design and implementation of components[11] [12]. Over the last 4 years our faculty has participated actively in SIGITE and attempted to share what we have learned with the emerging IT community [8] [9] [10] [11] [12].

The BYU curriculum has evolved into what IT2005 calls a “core/integration first” approach[13]. Significant portions of the introductory material in operating systems, databases, web systems, networking had been

moved to lower division courses by early 2004. Much of the shift occurred when the introduction to web systems was moved from the junior to the sophomore year and introductory material sufficient to understand web systems was included for networking, databases, operating system administration and OS process models. The improvements in flow and reduced redundancy have been noticeable in the upper division core courses. Appendix B graphs the current BYU course structure. In late 2004 and early 2005 we began implementing the “pervasive theme” of IAS in earnest.

VI. INTEGRATING IAS INTO THE EXISTING CURRICULUM

A senior level IAS class had been introduced into the curriculum in early 2004 and was made a requirement in 2005. However, we recognized that simply adding a required course at the end of a student’s college experience would not be adequate. SIGITE discussions had placed security in the pervasive theme category at the very beginning, though the name of the KA wasn’t chosen until 2004. We were faced with the challenge of integrating the IAS fundamentals into the introductory courses, morphing the security modules in the existing classes to use the MSRW [7] framework and bringing all of the students in the program up to speed on the new framework simultaneously.

Our approach has been to prepare one hour modules on the MSRW framework that can be used in an existing course to bring students up to speed or taught in seminars as needed. We are in the process of integrating the IAS Fundamentals into our introductory courses. We successfully integrated the IAS modules into the sophomore introduction to web-based systems course which was already introducing all of the major IT areas. The course was modified to replace a 3 week team project experience with a 2 week team oriented lab and then using the time for IAS topics. Much remains to be done, but the initial experience is positive. The faculty seems unified in their desire to implement IAS as a pervasive theme. For example, 2 lecture and 2 lab hours are now included in the computer communications course. 3 lecture hours and 3 lab hours were added to the web systems course. The IAS component of the database course was rearranged and strengthened with 1 lecture hour added. Similar adjustments have been made throughout the curriculum.

In addition to improving the IAS component of the BYU curriculum, we have done an analysis of our coverage of the proposed IT2005 core. We have several adjustments in other parts of our curriculum. Since we evolved from an EET program, the hardware coverage was extremely strong. We are weak in the coverage of systems and

database administration. We will continue to adjust our curriculum as IT matures as an academic discipline.

VII. SUMMARY

Information Technology is maturing rapidly as an academic discipline. A public draft of the IT volume described in the Computing Curriculum 2004 Overview is ready for review. The SIGITE Curriculum Committee is soliciting feedback on the document. This paper presents a brief history of SIGITE, the ACM SIG for Information Technology Education, and provides a context within which the Information Assurance and Security community can evaluate the IAS component of the curriculum. The paper also contains a brief history and status report on IAS within the IT program at Brigham Young University.

SIGITE and the CC 2004 Joint Task Force solicit feedback on the documents at <http://www.acm.org/education/>.

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IX. ACKNOWLEDGEMENTS

The authors would like to thank the ACM Education committee for their support of the IT2005 effort, especially Russ Shackleford, without whose financial support and encouragement the document would be years away from completion. We would also like to express appreciation to the NSA for funding the IAEGC program and Melissa Dark for the personal effort that makes it such a successful program; the true impact of their investment is just beginning to be felt. Corey Schou's IAEGC lecture on helping students understand IAS in an hour was the genesis of the IAS approach in IT2005. Finally we would like to express appreciation to our colleagues and the administration of the School of Technology at Brigham Young University, who covered our classes and found the funding for the time and travel our participation in the SIGITE curriculum committee required.

Appendix A

From IT2005 Mar 2005 Draft

The Information Technology Body of Knowledge

ITF. Information Technology Fundamentals (33 core)

- ITF1. Pervasive Themes in IT (17)
- ITF2. Organizational Issues (6)
- ITF3. History of IT (3)
- ITF4. IT and Its Related and Informing Disciplines (3)
- ITF5. Application Domains (2)
- ITF6. Applications of Math and Statistics to IT (2)

HCI. Human Computer Interaction (20 core hours)

- HCI1. Human Factors (6)
- HCI2. HCI Aspects of Application Domains (3)
- HCI3. Human-Centered Evaluation (3)
- HCI4. Developing Effective Interfaces (3)
- HCI5. Accessibility (2)
- HCI6. Emerging Technologies (2)
- HCI7. Human-Centered Software (1)

IAS. Information Assurance and Security (23 core)

- IAS1. Fundamental Aspects (3)
- IAS2. Security Mechanisms (Countermeasures) (5)
- IAS3. Operational Issues (3)
- IAS4. Policy (3)
- IAS5. Attacks (2)
- IAS6. Security Domains (2)
- IAS7. Forensics (1)
- IAS8. Information States (1)
- IAS9. Security Services (1)
- IAS10. Threat Analysis Model (1)
- IAS11. Vulnerabilities (1)

IM. Information Management (34 core hours)

- IM1. IM Concepts and Fundamentals (8)
- IM2. Database Query Languages (9)
- IM3. Data Organization Architecture (7)
- IM4. Data Modeling (6)
- IM5. Managing the Database Environment (3)
- IM6. Special-Purpose Databases (1)

IPT. Integrative Programming & Technologies (23 core)

- IPT1. Intersystems Communications (5)
- IPT2. Data Mapping and Exchange (4)
- IPT3. Integrative Coding (4)
- IPT4. Scripting Techniques (4)
- IPT5. Software Security Practices (4)
- IPT6. Miscellaneous Issues (1)
- IPT7. Overview of programming languages (1)

NET. Networking (20 core hours)

- NET1. Foundations of Networking (3)
- NET2. Routing and Switching (8)
- NET3. Physical Layer (6)
- NET4. Security (2)
- NET5. Application Areas (1)
- NET6. Network Management

PF. Programming Fundamentals (38 core hours)

- PF1. Fundamental Data Structures (10)
- PF2. Fundamental Programming Constructs (9)
- PF3. Object-Oriented Programming (9)
- PF4. Algorithms and Problem-Solving (6)
- PF5. Event-Driven Programming (3)
- PF6. Recursion (1)

PT. Platform Technologies (14 core hours)

- PT1. Operating Systems (10)
- PT2. Architecture and Organization (3)
- PT3. Computer Infrastructure (1)
- PT4. Enterprise Deployment Software
- PT5. Firmware
- PT6. Hardware

SA. System Administration and Maintenance (11 core hours)

- SA1. Operating Systems (4)
- SA2. Applications (3)
- SA3. Administrative Activities (2)
- SA4. Administrative Domains (2)

SIA. System Integration and Architecture (21 core hours)

- SIA1. Requirements (6)
- SIA2. Acquisition/Sourcing (4)
- SIA3. Integration (3)
- SIA4. Project Management (3)
- SIA5. Testing and QA (3)
- SIA6. Organizational Context (1)
- SIA7. Architecture (1)

SP. Social and Professional Issues (23 core hours)

- SP1. Technical Writing for IT (5)
- SP2. History of Computing (3)
- SP3. Social Context of Computing (3)
- SP4. Teamwork Concepts and Issues (3)
- SP5. Intellectual Properties (2)
- SP6. Legal Issues in Computing (2)
- SP7. Organizational Context (2)
- SP8. Professional and Ethical Issues and Responsibilities (2)
- SP9. Privacy and Civil Liberties (1)

WS. Web Systems and Technologies (21 core hours)

- WS1. Web Technologies (10)
- WS2. Information Architecture (4)
- WS3. Digital Media (3)
- WS4. Web Development (3)
- WS5. Vulnerabilities (1)
- WS6. Social Software

Total Hours: 281

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.

