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Experience Implementing IT2005 IAS Curriculum in Existing Programs

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Abstract – The IT2005 model curriculum describes Information Assurance and Security as a pervasive theme that must be integrated throughout the IT curriculum. The associated knowledge area provides a minimum set of outcomes for every IT student associated with this important subject. Implementing a knowledge area that is required across the entire curriculum is a significant challenge, since security has historically been given weak coverage in computing courses. In this paper we introduce the approaches used in two IT programs for implementing the IT2005 requirement for IAS as a "pervasive theme". We also include a brief introduction to IT2005 and the process that created it. It is our belief that any program that is preparing students to deploy computing technology in the current world environment should include security concerns in the curriculum. We hope that our experience can help others achieve this important goal.

Index terms – Information Technology, pedagogy, Information Assurance, Security

I. Introduction

The IT2005 Model Curriculum is the first significant effort to address information assurance and security in a manner that will be used for accreditation. This paper examines the role of information assurance and security in the IT2005 model curriculum, as well as how the associated components were conceived. Because the IT2005 model curriculum is being used for accrediting academic programs, we also thought there would be value is giving examples of how two institutions are implementing IAS in their curriculum that meet the accreditation requirements.

The Information Assurance and Security knowledge area in IT2005 [1] was created through the interaction of the Information Technology and Information Assurance education communities.[2] Information Assurance and Security is one of 8 (Figure 1) pervasive themes introduced IT2005. The curriculum 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"[3]. While these themes are referenced in various knowledge areas, Information Assurance and Security is the only one that is also a knowledge area (Figure 2).

Pervasive Themes in IT2005

1. user advocacy
2. information assurance and security
3. ethics and professional responsibility
4. the ability to manage complexity through: abstraction & modeling, best practices, patterns, standards, and the use of appropriate tools
5. a deep understanding of information and communication technologies and their associated tools
6. adaptability
7. life-long learning and professional development
8. interpersonal skills

Figure 1

ITF Information Technology Fundamentals
HCI Human Computer Interaction
IAS Information Assurance and Security
IM Information Management
IPT Integrative Programming & Technologies
NET Networking
PF Programming Fundamentals
PT Platform Technologies
SA Systems Administration and Maintenance
SIA System Integration & Architecture
SP Social and Professional Issues
WS Web Systems and Technologies

Figure 2

II. The IT2005 Process

As stated before, the IAS knowledge area in IT 2005 as it currently exists was the result of interaction among two communities: Information Technology and Information Assurance. However, this interaction was not in existence from the onset. Rather, it evolved over time.

The IT community that has become SIGITE, the ACM Information Technology Education SIG, began the formal organizational process in Dec. 2001 with a meeting near Provo, Utah. By the spring of 2006 SIGITE had held 6 academically oriented conferences and produced numerous conference papers to explain the process, [4 5 6 7 8 9 10 11 12] and its committees had produced drafts of the IT accreditation criteria with ABET [13] participated in the creation of the Computing Curriculum Overview Document (CC2005)[14] and the IT2005[15] model

curriculum. Three IT programs received accreditation through CAC of ABET in 2005 under the general criteria. One program received a pilot visit in November of 2005 and the outlook is positive for accreditation under the draft IT criteria. The IT community received international attention with presentations at conferences in South America, Europe, and China. And many IT programs are well on their way to implementing the IT model curriculum.

The IT2005 writing committee described the process that was used at ISECON 2005 [16]. At the first CITC meeting there was a Delphi study using "sticky" notes where all of the participants listed topics that they thought were core to IT education. These were organized by the group and then a written summary was prepared. This provided 34 groupings, which were later reorganized further. This list of topics formed the basis of the body of knowledge. Similar exercises were performed at several universities with their Industrial Advisory boards that verified the initial results and provided additional input.

During the same period, a consensus definition of IT was drafted: "*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*." The accreditation committee used this definition to formulate the program educational objectives and program outcomes: which have been thoroughly reviewed by over 40 universities with IT programs and several industrial advisory boards at those institutions.

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.

During this process, the concept of "pervasive themes" emerged to cover outcomes that seemed to occur in many of the Knowledge Areas. One of the most pervasive themes was "Security". The curriculum committee did not achieve consensus on a suitable model for either this theme or for the entire KA until the MSRW model [17] was discovered (Figure 4). Based on interaction with the IA community, the name chosen was Information Assurance and Security (IAS).

III. Information Assurance and Security in the IT2005 Model Curriculum

If a knowledge area (KA) is to be "threaded" through a curriculum, the framework must be introduced early, reinforced throughout the curriculum, and also elaborated on throughout the educational process. Fortunately, IT2005 uses a model that:

1. can be understood by freshman IT students
2. can provide a framework to integrate IAS concepts that are integrated into nearly all of the other KAs
3. is robust and comprehensive enough to support a senior level course that ties everything together.

Figure 3 lists the IAS KA with its areas. The basic structure and vocabulary is derived directly from work done in the IA community, specifically Maconachy, et. al.[17]. 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 units in all of the KAs, is first "Fundamentals", if there is one, and then the units 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.

The MSRW model is a cube (see Figure 4) that 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, and is comprehensive enough to encompass a capstone learning experience.

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)**

Figure 3

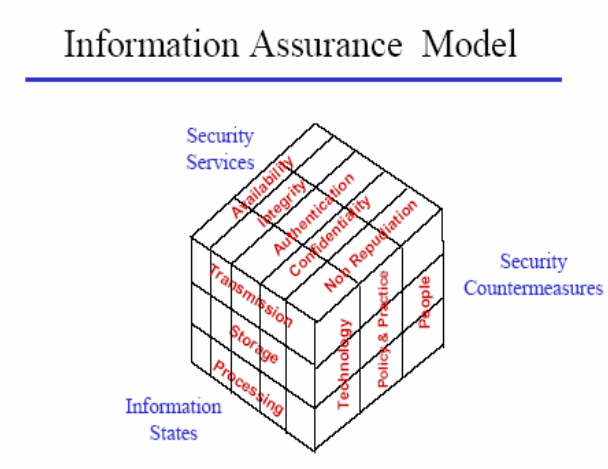

Figure 4

IV. Integrating IAS into the BYU Curriculum

The BYU curriculum has evolved into what IT2005 calls a "core/integration first" approach1 [8]. 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. In late 2004 and early 2005 we began implementing the "pervasive theme" of IAS in earnest.

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 [19] 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 other major IT areas. The course was modified to replace a 3 week team project experience with a 2 week team oriented lab, which allowed time for IAS topics. This includes an introduction using the MSRW model, an introduction to buffer overflow issues, a brief introduction to the concepts of PKI and an introduction to media analysis with a simple lab. The initial experience has been positive. The faculty seems unified in their desire to implement IAS as a pervasive theme. For example, 2 lecture and 3 lab hours focused on IAS are now included in the computer communications course and 3 lecture hours and 3 lab hours focused on IAS were added to the web systems course. The IAS component of the database course was rearranged and strengthened with 1 lecture hour focused on IAS added. Similar adjustments have been made throughout the curriculum.

While the initial experience has been positive, much work remains. For example, our introductory networking course needs to include more security related material and we are implementing a Computer Forensics course as an elective for seniors, though we think that the emphasis should be more along corporate lines as suggested by Logan [20] rather than the usual law enforcement oriented approach. We have also been experimenting with courses on data privacy and integrity.

V. Integrating IAS into the Existing Purdue Curriculum

The primary approach to date in the Computer and Information Technology department at Purdue University has been to treat IAS as a knowledge area. Two senior level IAS classes have been introduced into the curriculum at Purdue University. The first is entitled Network Security and the second is Introduction to Cyberforensics. There is also a Biometrics course offered in another department that CIT students at Purdue can take. In addition, we are currently developing an Applied Cryptography class for undergraduates. The combination of these four courses addresses most of the topics outlined in the Information Assurance and Security knowledge area of IT 2005.

In addition, at Purdue University some of the fundamental aspects (IAS1) and operational issues (IAS3) are covered in introductory and intermediate courses in both our Network Engineering Technology (NET) and our Information Systems and Technology (IST) degree options. In addition, conversation has begun at Purdue University to extend an information assurance and security service learning course that was developed for graduate students to NET and IST undergraduate students. In the course, students work in teams for a non profit

client organization that has an information security need or problem. In service learning students learn and develop through active participation in thoughtfully organized service experiences that meet actual community needs, that are integrated into the students' academic curriculum or provide structured time for reflection, and that enhance what is taught in school by extending student learning beyond the classroom and into the community. Service learning joins theory and practice, i.e., students experience the relevance of the subject to the real world. We also anticipate that we would develop the course using problem based learning as a predominant instructional strategy. The problem based learning cycle (Figure 5) is especially powerful when the objective of instruction is to teach students how to utilize facts, concepts, and principles to solve ill-structured problems, i.e., problems that often do not have a single correct solution. This is quite appropriate in the information assurance and security domain.

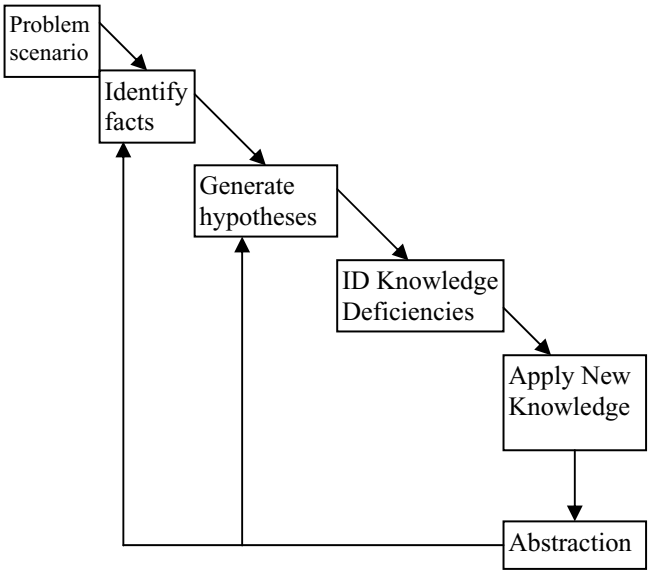

Figure 5

In addition, the IAS courses serve the purpose of helping students achieve the broader program outcomes. At Purdue we have found that our IAS courses map to the following IT program outcomes.

General student outcomes:

1. ability to apply knowledge of computing and mathematics appropriate to the discipline;
2. ability to function effectively on teams to accomplish a common goal;
3. understanding of professional, ethical and social responsibilities;
4. ability to analyze the impact of computing on individuals, organizations and society, including ethical, legal, security and global policy issues;
5. recognition of the need for, and an ability to engage in continuing professional development;
6. ability to use current techniques, skills, and tools necessary for computing practice.

Specific student outcomes:

1. ability to use and apply current technical concepts and practices in core information technologies;
2. understanding of best practices and standards and their application;
3. ability to assist in the creation of an effective project.

VI. Summary of Implementation Approaches

In this section we categorize the techniques that we have used to integrate the IAS knowledge area from IT2005 into our programs.

A. Slip-streaming:

This approach requires the opportunistic insertion of current events into discussions in the existing curriculum. For example, during a discussion of C I/O one could take 5 minutes and discuss how one of the SMTP buffer-overflow problems allowed a root kit to insert its code into a buffer and execute it because the code assumed that no one would ever enter more than 2000 characters without an end of line. It would also be wise to point out that one should probably never use unbounded routines like "gets" and "puts" in production code because you are creating potential buffer overflow conditions every time they are used.

B. Mini-topics:

This approach requires the preparation of 5-10 minute topic presentations covering IAS issues such as buffer-overflow and the dissemination of the curriculum materials to the faculty so that it requires minimal preparation to insert IAS content into existing lectures.

C. Complete lectures:

This approach is useful when remedial instruction must be inserted into an existing course for students that attended a course before a topic was integrated into the current perquisite. The creation of 1 hour stand-alone lectures on various topics also allows one to easily create seminar sessions to help lab and teaching assistants understand the changes to content of courses as they evolve.

D. Modules of instruction:

We have found that some topic areas simply don't fit into a 1 hour format. For example, if one wanted to include

digital forensics and media analysis in an operating systems class, one could insert a module on evidence gathering and chain of custody along with the technical aspects of media analysis. It is interesting that some students commented that they never understood file systems until they dissected them using forensic tools, thus providing a secondary benefit of the integration.

E. Companion courses:

This approach takes an existing 3 credit hour technical course (such as Operating Systems) and adds a 1 credit hour companion course that focuses on IAS issues as they relate to the topic of the 3 credit hour course.

F. Complete courses:

This is the most common approach to adding content to a curriculum. We have found that great efficiency in presentation can be gained by looking at course outcomes of the curriculum as a whole and then refactoring topic coverage to incorporate fundamental concepts early. In one case we found that certain topics were being covered 3 times at an introductory level in upper division courses because they didn't share a common prerequisite and could be taken in different sequences. Putting introductions to operating systems concepts, databases, information assurance, networking, and system administration into a sophomore course freed 2-4 weeks of contact hours in each of our junior core courses. The additional time was used to include coverage of more advanced concepts.

G. Problem based service learning courses:

This is not the most common course approach and it does require a great deal of organization. The role of the instructor shifts from delivering content to arranging for learning experiences that require students to 1) apply previously learned skills along with 2) identify new knowledge that may be required. Once students identify the need for new knowledge, the role of the instructor is to facilitate finding resources so that students can "self-educate" with guidance. An approach such as this can be effective when 1) it is desirous to provide a powerful learning experience that has the ability to reinforce the pervasive nature of security, and 2) when it is difficult to get coordination across a large number of courses to integrate IAS a "little bit in a lot of courses".

VII. Conclusion

Information Technology is maturing rapidly as an academic discipline. A public draft of the IT volume described in the Computing Curriculum 2005 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 a brief description of the process used to define the model curriculum. We have discussed the integration of Information Assurance and Security concepts into IT2005 as a "pervasive theme" and have given examples of how two existing IT programs have integrated IAS concepts into their curriculum.

In conclusion, we believe that a weakness in many computing programs is the inadequate treatment of security topics throughout the curriculum. The IT2005 model curriculum has benefited significantly through collaboration between the Information Assurance Education and IT Education communities. It is an axiom of system development that security is built in more effectively that it is added on. The IT2005 curriculum document requires that IAS be treated throughout the curriculum and we have given examples of how this can be accomplished

We have demonstrated that it is possible to integrate Information Assurance and Security concepts as a pervasive theme into an existing IT curriculum as is recommended by IT2005. We believe that the approaches we have used can be applied in other computing disciplines.

SIGITE and the CC 2005 Joint Task Force solicit feedback on the documents at http://www.acm.org/education/ .

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