Designing an Interdisciplinary Information Technology Program

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ABSTRACT
We examine key factors in the design and implementation of an Information Technology (IT) major and discuss the limitations encountered in creating a new program in a resource constrained environment. The focus is on four factors. First, we discuss a learning model appropriate for IT majors who need to be prepared for graduate study in IT, the military IT environment, and the civilian IT world. Second, we examine the strengths and weaknesses of implementing the learning model by using existing courses offered by an existing organization. Third, we discuss ways to mitigate potential weaknesses of this approach. Finally, we discuss a continuous assessment and improvement process to evaluate and improve the success of the implementation.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education – Information Technology Education.

General Terms
Management, Measurement, Standardization

Keywords
Information Technology Curriculum, Interdisciplinary

1. INTRODUCTION
Information Technology (IT) is the newest of the computing disciplines in American higher education, joining more established disciplines such as computer science, computer engineering, software engineering, and information systems. The expanding number of undergraduate IT programs parallels the growing need for IT professionals in businesses that wish to maintain a technological edge in today's marketplace. At the United States Military Academy (USMA), the fact that IT is a key factor in transforming the Army was an additional motivation for developing an IT major to prepare future Army Officers with a solid background in IT. Yet, USMA is a small institution with limited resources. Accordingly, we have undertaken to implement the IT major using existing courses combined with a few new courses. We do this while still meeting the unique IT objectives of the program by using a learning model based on depth threads – 3 course sequences built around a common theme. We use courses drawn from other programs combined with a few new courses, and we use existing faculty to teach these courses. Aware of the risks of this approach, we undertake the effort to understand and mitigate those risks. We also initiate a continuous assessment process to evaluate and improve our implementation. As with the curriculum, the assessment process uses and integrates a diversity of assessment instruments and indicators that are already in use by other curricular programs at our institution.

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2. BACKGROUND
The history of the computing disciplines taught by American colleges and universities has been led from the beginning by the Association for Computing Machinery (ACM). Specifically, the ACM has led the development of Computer Science with Model Curricula published in 1968, 1978, 1991, and 2001 [1].

The ACM model curriculum in computer science has always had a theoretical and mathematical orientation; yet, some have felt there was a need for a curriculum with greater focus on the application of information technologies. During the 1990's a small, but growing number of universities were developing computing curricula that were alternatives to the traditional computer science curriculum of the ACM. Often, these alternatives had an emphasis on the use of the technologies that underlie the World Wide Web: networks, databases, web site development, and human computer interactions. Among the earliest IT curricula were those offered by Rochester Institute of Technology [9], Brigham Young University [7] and Georgia Southern University [8]. With the leadership of these early programs, the Society for Information Technology Education (SITE) held several national level meetings to a growing number of participants over the period 2001-2003.

In the CC2001 curriculum volume, the ACM proposed four subordinate volumes for model curricula in computer engineering (CE), computer science (CS), software engineering (SE), and information systems (IS). In 2003, ACM invited the SITE organization to become an ACM Special Interest Group for Information Technology Education (SIGITE). In response to the growth of the SIGITE organization, ACM included Information Technology as the fifth subordinate volume of its CC2005 curriculum overarching volume [2].

Subsequently, SIGITE has produced its IT2005 curriculum volume in record time [3]. The Information Technology draft Model Curricula incorporates the lessons learned and consensus built among the institutions that first developed IT programs, thus providing a roadmap for future Information Technology programs at other institutions.

ABET, Inc., is the recognized accreditor for college and university programs in applied science, computing, engineering, and technology. In recent years, ABET has expanded to accredit all programs in the computing disciplines. Much like the ACM Computing Overview Report, the ABET accreditation requirements specifies general requirements for all computing disciplines and discipline-specific requirements for computer science, information systems, and most recently, Information Technology.

In 2003, USMA's Department of Electrical Engineering and Computer Science began development of a Information Technology major to complement programs in electrical engineering and computer science and to better meet the needs of our constituent. This was motivated and demanded by the growing use of IT in the United States Army to transform its processes [6] in much the same way that IT is transforming processes in the business sector. Yet, we were challenged to implement this initiative without any additional resources. This paper describes the development of this IT program at USMA.

3. IMPLEMENTING AN IT CURRICULUM

Any university that develops an IT curriculum must decide how to implement it. Perhaps the most common approach is to introduce a new IT organization with new faculty, courses, and facilities dedicated to the IT program. Examples include Brigham Young University, Georgia Southern University, Rochester Institute of Technology, New Jersey Institute of Technology, Rensselaer Polytechnic Institute, Radford University, George Mason University, University of Maryland-University College, University of South Alabama, Macon State College, Purdue University, University of Houston, and many others.

The great advantage to this external approach is the excitement and enthusiasm it can generate in faculty and students in the program who unite in allegiance to a new professional identity. The shortcoming of this external approach is its heavy initial resource demands as faculty, staff, and facilities are allocated to the new curriculum and heavy, short-term development demands as new courses must be developed and new students recruited and managed by a fledgling organization. Another shortcoming of the external approach is the resentment incurred from faculty in other units from which new resources are possibly reallocated.

A second internal approach is incubation of the new program within an existing organization, employing no additional faculty or new courses. Most commonly, when an IT curriculum is implemented in an existing unit, IT is incorporated into an existing Computer Science (CS) organization or that of another closely related field and staffed with existing faculty.

An interesting alternative is to begin with the latter internal approach and gradually migrate to the former external approach. This hybrid method is discussed in Alford, et.al [4, 5].

There are several significant advantages to this hybrid approach. The hybrid approach:

- uses existing in-place resources and gradual development of new courses and new facilities over time,
- is especially viable in an existing Computer Science (CS) organization that is experiencing the declining enrollment that seems to be a national trend,
- gives an interdisciplinary nature to the curriculum (because the courses can be drawn from multiple other programs) that is remarkably suitable to the mission of IT graduates as organizational integrators,
- achieves a diverse classroom as students from multiple disciplines experience learning in an environment that more closely resembles the professional environment into which students will graduate,
- offers faculty the opportunity to collaborate with one another across disciplines thus encouraging their own professional development as members of multi-disciplinary teams, making them familiar with the challenges of discipline integration that their students will face at graduation.

The weaknesses of the hybrid approach are:

- the potential for students to fail to develop a sense of community or professional identity when they perceive that courses are not designed for them and not taught by a faculty committed to their program,
- the additional effort required of faculty to build connections across and integrate courses that are drawn from multiple programs,
- the additional effort required of faculty to relate to a diverse student classroom drawn from multiple major programs.

Possible mitigators of the hybrid approach include:

- strong management support for the integrated perspective,
- implementation of some new courses that are exclusively for the IT majors to begin to build the professional identity of those students,
- frequent and regular informal meetings of faculty from the multiple programs to brief their courses to one another and to share their experiences,
- regular involvement of faculty with industry and business organizations that are dependent on IT. Fortunately, at USMA sixty percent of our faculty are active duty officers on a three year assignment. They are IT practitioners who come from and return to active operational environments in which IT is daily transforming the nature of Army processes.

4. LEARNING MODEL

The learning model that serves as the foundation for the USMA's Information Technology (IT) academic major is designed to ensure appropriate preparation for graduate study and to provide the ability to succeed in both the military IT and civilian IT environments. Our learning model describes the structure, process, and content of the curriculum and student learning experience paralleling USMA's format [10].

The generic structure of our IT learning model is shown in Figure 1. A solid overall foundation in engineering, mathematics, basic sciences, and the behavioral and social sciences provides interdisciplinary breadth. Introductory IT course(s) provide an overview and broad IT foundation. Our model achieves academic depth by using several three course sequences called Depth Threads. Depth Threads combine existing courses in an innovative manner resulting in students discovering an identified pervasive concept. This Depth Thread paradigm is discussed in detail in [4, 5]. IT breadth is achieved by taking multiple, diverse threads. The model's culminating experience is a senior-level, interdisciplinary integrative experience that emphasizes application of principles learned.

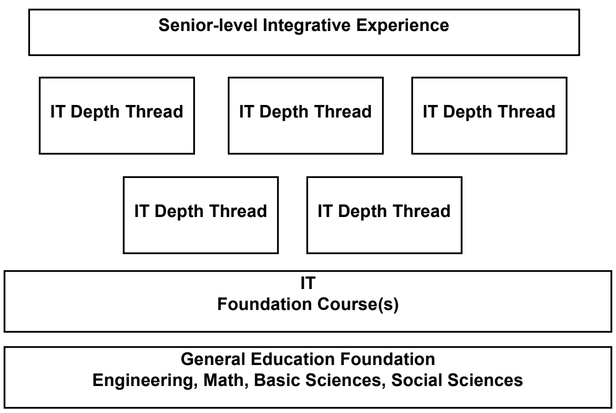

Figure 1: The generic structure of the learning experiences for USMA's IT major.

The process of our IT learning model is based on knowledge discovery through a graduated series of problems that must be solved. In some cases, these problems may require a few hours to solve; others may require several weeks. In many threads, the size and complexity of the problems increases throughout the sequence of courses as students learn how to manage the problem-solving process. In some advanced courses, the entire term is spent solving a single problem. The desired outcome of the program is that each student will learn the analytic skills required to investigate a problem involving technology, build an analytical model of the solution space, develop and compare alternative solutions, make an informed, reasoned choice of the best one, and, in many cases, implement it in the context of the target human population of users.

The content of the learning experience begins with the introduction of this process paradigm in the foundational courses, continues with exposure to the paradigm in the context of the traditional knowledge structures and approaches of the discipline, and concludes with an integrative experience that demonstrates mastery of the paradigm in the full complexity of social, political, and economic terms as well as technological context. Mastery is demonstrated by the creation of a significant problem solution that can be objectively evaluated for success with respect to fixed criteria relevant to actual applications and, wherever possible, Army applications.

The Information Technology curriculum at USMA was developed two years ago using a two step process that began with the development of learning objectives obtained from the recurring and pervasive concepts we teach by classroom inquiry and discovery. The development process then continued by using five three-course threads that are used to reveal recurring and pervasive concepts. The significance of this methodology for our department was the ability to use existing courses (from multiple disciplines) and thus to minimize the impact on existing resources while presenting an opportunity for gradual and managed curricular change [4, 5].

The central core of the IT major is the body of method, theory, and tools employed to harness IT and includes elements of computer science, electrical engineering, information systems, systems engineering, human factors engineering, physics, remote sensing, and other established disciplines from which the courses of the IT major are drawn. However, IT is necessarily not just a combination of these disciplines. Rather the IT course selections are focused on the methods, theories, and tools of these disciplines that *explain principles and allow one to analyze the characteristics and capabilities of technologies for purposes of problem solving by combining them in systems*—generally the science-oriented courses of these curricula. On the other hand, the IT major is distinguished from any of the related majors in that it does *not* emphasize the detailed understanding of design and construction of the individual technological artifacts, which are the purview of engineering curricula but rather emphasizes the use and exploitation of technological artifacts. The instantiation of our IT major upon our learning model structure is shown in Figure 2.

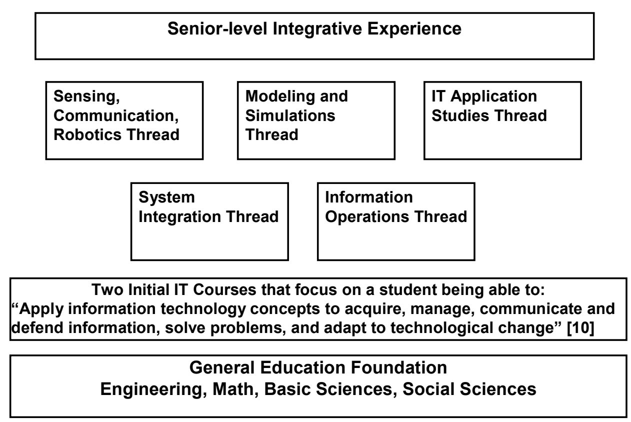

Figure 2: The instantiated structure of USMA's IT major learning model.

The core course requirements taken by all students for a USMA Bachelor's of Science degree provide a very strong general education foundation. Two IT courses provide an excellent introduction and foundation covering such topics as basic programming constructs, data acquisition, networking, web development, databases, information systems, information assurance, laws, and ethics. The IT major achieves both depth and breadth through five Depth Threads. Each thread has prerequisite or other logical structure that also imparts depth. The requirement to complete five diverse Depth Threads also imparts IT breadth. The IT major Depth Threads are multi-dimensional and range from the sensing and representation of the physical world, to the transmission and processing of information, to the analysis and presentation of information used to make decisions and control actions. Through this use of the Depth Thread paradigm, we were able to implement the IT curriculum by developing two new courses, reorienting several existing courses, and otherwise using existing courses in new and meaningful ways. Further specific details on USMA's current curriculum can be found at www.eecs.usma.edu/it/.

5. ASSESSMENT AND IMPROVEMENT

Having developed our curriculum and learning objectives, the next step was to develop program outcomes and the tables that cross-walk these outcomes to assess both our local IT program objectives and also support the Characteristics of an IT Graduate (a)-(k) that have appeared in the Information Technology Volume of the ACM Computing Curricula series [3]. These program outcomes are then injected into the assessment process used by the Department of Electrical Engineering and Computer Science to assess all its programs. The goals of this process are to help identify areas of excellence and areas of concern, foster increased communication and awareness among faculty, and inspire continuous critical review and revision of teaching goals while not imposing undue work, prescribing or dictating classroom activities, or invoking defensive reactions.

To this end, numerous sources of assessment data are used including

- assessment data used in the institutional level assessment processes,
- annual reports generated inside the department,
- the ABET self-studies,
- the battalion commanders' survey,
- reports of the department advisory board,
- institutional and departmental visitors,
- student participation in external conferences,
- student competitions (design, paper, programming),
- Cyber Defense Exercise (CDX),
- judging by external judges on Project's Day,
- faculty and program-level discussions,
- survey of graduating cadets.

Formal assessment (that occurs within the context of all these supporting sources) includes comparison with the IT model curricula, an outcome monitor process, and course summaries and proposals. Of these, the comparison with model curricula is well understood while the other two deserve explanation.

A faculty member is designated as the outcome monitor for each of the program outcomes. This outcome monitor is responsible for:

- identification of necessary and sufficient vehicles for indicating achievement of the outcome,
- collection and summary of data that supports the outcome,
- development of rubrics for the outcome,
- evaluation of the outcome by applying the rubrics to the data,
- archiving representative student work for the outcome.

The course summaries and proposals are developed by the course director for each course in each term the course is taught. The course director is responsible for:

- design and evolution of the course objectives,
- design and delivery of learning experiences to support course objectives,
- identification of program outcomes supported by the course,
- identification of embedded indicators for assessing those program outcomes,
- collecting and evaluating data from embedded indicators,
- development of the course proposal and summary discussed further below.

At the beginning of each term, each Course Director presents a written Course Proposal to the Program Director and then presents a written Course Summary at the end of the term. However, these are perhaps best thought of in reverse. The Course Summary of the preceding Course Director is combined with the Course Proposal of the incoming Course Director to propagate the continuous improvement model that is the motivation for assessment.

The assessment of a program's objectives being met is key to the future success of a program. Often this process is expensive and time consuming, which often exceeds the capabilities of a normal-sized program. The establishment of an institutional level assessment program can coordinate efforts, share costs, and provide valuable data for many organizations. In addition, an effective mix of data from a variety of data collection inputs can more accurately portray the state of achievement of the program's graduates.

Surveys are the most common type of assessment tool. At USMA, a special office has been created to coordinate the collection and distribution of survey data. This office works with the Association of Graduates to track our graduates' whereabouts and current positions. Thus, we can get a higher percentage of our population surveyed compared to other institutions. Surveys are also distributed to the supervisors of our graduates, which often provides an interesting point of reference.

USMA takes advantage of the Army educating its most successful senior officers at the Army War College -- a year long course dedicated to the study of military strategy. Since many USMA graduates have worked for these senior officers, a team is sent annually to interview these officers on our graduates' performance. As with the surveys, each program can provide questions to be answered.

Another common assessment tool is the advisory board. Each program at USMA has an advisory board and there is also an academy level board of visitors. The IT program interfaces with a

12 member advisory board along with the computer science and electrical engineering programs. Another USMA feature is that funding for the advisory boards comes from the Dean's office, not the individual programs. Contact with advisory board members is increased by inviting members of the advisory board to be judges at projects day and presenters at the end of the year.

6. CONCLUSIONS

Information Technology is a significant curricular innovation in American higher education. Many institutions have started IT programs and other institutions are considering whether they can. The challenge for a small institution with limited resources is how to initiate a new program when existing resources are fully committed. We have outlined our experience with this undertaking and have suggested that the task can be accomplished if approached with an appropriate learning model and with a commitment to success.

When developing the learning model, particular attention needs to be paid to the depth and breath of the IT program. The established core curriculum as well as the base computer science and electrical engineering courses provide the necessary depth in providing the foundation necessary for an IT program. Due to the diverse nature of IT applications, it is possible to use courses from multiple disciplines to provide a breadth experience for an IT program. A culminating design experience is necessary so that each student has the opportunity to demonstrate their newly acquired skills and knowledge.

One of the most essential parts in the startup of a new IT program is the ability to use assessment tools already in place. The most accurate picture of a program is provided by a variety of data collection sources. Much of this data comes from within a program, but often data that can be collected outside the program is neglected. Resource sharing is important facet of data collection that can help limit the overhead of and the duplication of parallel efforts. Through careful planning and by researching the development of other IT programs, the initialization of an IT program will have a much greater chance of success.

7. REFERENCES

[1] ACM and IEEE Computer Society. Computing Curricula 2001 Computer Science. *ACM Journal of Educational Resources in Computing*, 1, 3, 2001. (at http://acm.org/education/curric_vols/cc2001.pdf)

[2] ACM and IEEE Computer Society. Computing Curricula 2005. *The Overview Report*. ACM and IEEE Computer Society, 2005. (at http://www.acm.org/education/curric_vols/CC2005-March06Final.pdf)

[3] ACM Computing Curricula, Information Technology Volume. ACM, 2005. (http:// www.acm.org / education / curricula.html#IT2005)

[4] Alford, Kenneth L., Curtis Carver, Daniel Ragsdale, Eugene Ressler, and Charles Reynolds. "Specification and Managed Development of Information Technology Curricula." *SIGITE'04*, Salt Lake City, Utah, October 28-30, 2004.

[5] Alford, Kenneth L., Curtis A. Carver, Eugene K. Ressler, and Charles W. Reynolds. "A Curriculum Framework for Evolving an Information Technology Program." *34th ASEE/IEEE Frontiers in Education Conference.* October 20 – 23, 2004, Savannah, GA.

[6] *Army Regulation 25-1: Army Knowledge Management and Information Technology*. Headquarters, Department of the Army, Washington, DC. 15 July 2005.

[7] Brigham Young University, College of Engineering and Technology, School of Technology, Provo, UT. (at http://www.et.byu.edu/sot/it/)

[8] Georgia Southern University, College of Information Technology, Statesboro, GA. (at http://cit.georgiasouthern.edu/)

[9] Rochester Institute of Technology, B. Thomas Golisano College of Computing and Information Sciences, Rochester, New York. (at http://www.it.rit.edu)

[10] United States Military Academy. *Educating Future Army Officers for a Changing World*, 2003. (at http://www.dean.usma.edu/support/aad/efaocw.pdf)