Opportunities and Challenges to Developing A Bachelor's Degree Program in Information Technology

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Abstract

The rapidly changing Northern Virginia information technology (IT) workforce has a continuing need for competent, effective IT professionals. Competent professionals are well grounded in both the principles and practice of IT and are able to take care of standard requests from their customers. George Mason University's School of Information Technology and Engineering (IT&E) is committed to continually reviewing, evaluating, and improving its curricula so as to meet the changing needs of the Northern Virginia area and the nation.

While no silver-bullet solution to the IT worker shorter exists, multiple and creative ways to attack this problem are needed. One source of IT labor that is not being fully exploited is the potentials for movement of people who are already in the workforce, many who have non-traditional technical preparation, into the ranks of the IT professional. Traditionally, this has required returning to college for a second bachelor's or graduate degree in an IT-related field. Completing such a program while remaining employed typically takes from four to six years and a correspondingly high level of dedication and sacrifice. There are many more who are currently working in a technical field who would make this move to become an IT professional if there were more reasonable and practical ways to accomplish it. This Bachelor's of Science in Information Technology (BS IT) program fills the gap between training/associate's degree programs and graduate programs.

This paper discusses challenges and opportunities encountered while developing a curriculum to achieve these outcomes—a curriculum to educate industry-ready IT professionals. The curriculum is a four-year bachelor's degree program that focuses on areas of concentration during the last two years. This new undergraduate program is perfectly suited for the student who does not enter with a formal training in computing as well as for the student who might not have a love for theoretical aspects of the mathematical and natural sciences. The jobs that IT majors are expected to fill focus on the application of computer and communication technologies in other disciplines. The new BS IT curriculum is sufficiently flexible to serve existing, emerging, and future IT educational needs while preserving the integrity of existing degree programs in disciplines such as

computer science and management information systems. This new IT curriculum serves a wider variety of student and industry needs than do existing programs.

I. Overview of Paper

This paper discusses opportunities seized and challenges encountered while developing a four-year Bachelor's of Science in Information Technology (BS IT) program, and it provides some essential insight for other universities contemplating similar programs. We begin with a discussion of the BS IT program within the context of the mission of our School of IT&E. We then present a summary of some of the invaluable input that we used to establish the boundaries of the BS IT program. A major source for this input was faculty representing various George Mason University academic units (e.g., our School of IT&E, School of Management (SOM), College of Visual and Performing Arts (CVPA), and College of Arts and Sciences (CAS)), as well as representatives from the Virginia Community College System (including Northern Virginia Community College (NVCC) campuses, Lord Fairfax, and Germanna). Next, we present detailed information on the resulting BS IT curriculum and program structure. Finally, we discuss the challenges that we had to overcome throughout the various stages of the BS IT program development process. The BS IT program will help achieve our goal, which is to produce more graduates who understand information and who can use it effectively. The resulting BS IT program allows us to approach the notion of IT education in a completely new and revolutionary manner.

II.   Contextual Basis for the BS IT Program

George Mason University now serves approximately 25,000 students and is located in Northern Virginia—an area known as the "Internet capital of the world"—one with a very large number of high technology companies. To a greater extent, the high tech industry in this region has been responsible for an ever-increasing demand for technology savvy professionals; however, there is an increasing demand in the public sector and non-technology companies as well.

Our School of Information Technology and Engineering strives to meet the needs of the Northern Virginia high technology community. We justify the absence of offerings in traditional engineering programs such as chemical and mechanical by emphasizing that we are a non-traditional, information-based engineering school with innovative faculty. In fact, we were one of the first universities in the nation to focus on the IT aspects of engineering, and we have remained responsive to the changing needs of the Northern Virginia high technology community.

When reviewing the undergraduate education mission of the School of Information Technology and Engineering, which is to provide a quality education to support the IT and engineering needs of Virginia and the nation, the need to educate a new type of undergraduate student becomes apparent. This new type of student is one who is versed in the technical aspects of IT, but whose role in the modern enterprise will focus on the use and management of IT resources rather than the development of leading-edge intellectual property. The Bachelors of

Science in Information Technology (BS IT) degree program aims to meet these existing and emerging needs of the information technology industry by educating new IT workers in current principles and practices in information technology and their applications. The program's graduates have the basis for productive careers in this rapidly expanding IT industry, which is now a major component of the nation's and world's economies.

For a number of years now, our School of Information Technology and Engineering has offered a broad spectrum of Master's of Science and Ph.D. degree programs in information technology, computer science, and engineering. Our undergraduate offerings have been limited to Bachelor's of Science degrees in computer science and engineering, as well as an extremely popular IT Minor for non-IT&E students. The recent local and national surge in interest and reliance on information technology makes the present time perfect for offering the BS IT degree, filling the gap in our School of IT&E's undergraduate program offerings.

While no silver-bullet solution to the IT worker shorter exists, multiple and creative ways to attack this problem are needed. One source of IT labor that is not being fully exploited is the potentials for movement of people who are already in the workforce, many who have non-traditional technical preparation, into the ranks of the IT professional. Traditionally, this has required returning to college for a second bachelor's or graduate degree in an IT-related field such as Computer Science or Management Information Systems. Completing such a program while remaining employed typically takes from four to six years and a correspondingly high level of dedication and sacrifice. There are many more who are currently working in a technical field who would make this move to become an IT professional if there were more reasonable and practical ways to accomplish it. Many of these students are increasingly pursuing professional and continuing education programs similar to our School of IT&E's newly implemented Train to Technology (TTT) program. Some are pursuing certificates or degrees such as Associate's in Applied Science in the Virginia Community College System (VCCS). This BS IT program fills the gap between training/associate's degree programs and graduate programs.

III.   Establishing the Boundaries of the BS IT Program

A careful review of the IT literature and university publications revealed several innovative IT curricula, but failed to identify any IT curriculum that was well-suited to the needs of the Northern Virginia high technology community [2,13]. Through the efforts of several brainstorming sessions, invaluable input was collected from faculty representing various George Mason University academic units (e.g., our School of IT&E, School of Management, College of Visual and Performing Arts, and College of Arts and Sciences), as well as from the Virginia Community College System (including Northern Virginia Community College campuses, Lord Fairfax, and Germanna). In addition to identifying the essential intellectual skills for students in the new BS IT major, another benefit of the BS IT working committee's efforts was a thorough review of both the CS and DMIS curricula.

The following is a summary of the insightful guidance for initiating the BS IT proposal development process that was provided by the BS IT proposal working committee:

- Solicit industry input to establish need for the IT Major.
- Develop goals for the IT Major, and determine how these goals will be assessed.
- Keep in mind why we cannot produce enough CS and engineering majors to meet workforce demands.
- Determine what types of jobs the BS IT program will prepare students for.
- Determine the demand for the BS IT graduates.

- Determine potential student demand for the BS IT major.
- Examine existing IT type majors to determine why they are attractive to community college students.
- Decide early on the extent of the IT Major.
- Determine types and levels of skills that would be sufficient for the IT workforce.

- Ensure that the BS IT program is not simply a training program.
- Prepare students who are capable of pursuing masters degrees and other advanced academic programs.
- Determine the essential math requirement for the BS IT program.
- Determine the essential programming requirements for the BS IT program.

- Establish admissions criteria.
- Identify candidates for BS IT major (e.g., TTT, IST, high school academy, change of major students).
- Determine essential advising strategies to ensure smooth transition into BS IT major.
- Address issued associated with using non-credit type courses for credits toward an academic degree.
- Address issues associated with courses that have been taken mainly for a "terminal" associate degree.

- Determine essential curricula, including core and concentration related courses.
- Take into consideration special needs of the part-time working prospective student.
- Note that community college IST programs already have IT specializations.
- Certifications should be desirable but not requirements.

- Determine administrative, faculty, staff, and other resource demands.
- Estimate impact on existing programs and courses.
- Determine the need for new courses.

- Explore various strategies for delivering instructions.

Using these ideas as guideposts, the BS IT program boundaries were carefully crafted so as to exclude items considered to reside within the domain of disciplines such as CS and MIS. Our resulting design of the BS IT major does much more than simply tell us what lies within its boundary; hopefully, the description is tight enough for affected interests to determine what does not fall under the BS IT program's umbrella as well.

IV. BS IT Curriculum and Program Structure

Students in the BS IT degree program will take IT foundation courses as well as a well-defined set of IT core courses. Through this curriculum, students obtain a solid understanding and knowledge of a broad range of IT areas including databases, information security, networks, computers, Web development, and telecommunications. In order to complete the degree, students must choose a concentration in one of two high-demand IT knowledge areas: Computer Graphics and Web Development or Information Security and Network Administration. Each concentration includes a six-hour capstone design project. The significant difference between the BS IT curriculum and our Computer Science (CS) curriculum is the de-emphasis on the theoretical aspect of computing, mathematics, and natural sciences [2,11,14]. The major distinction between the IT curriculum and the Management Information Systems (DMIS) program, which is offered by the School of Management, is that courses in business comprise the core and major related courses for the DMIS curriculum [6,7,9]. In the DMIS curriculum, IT is taught within the context of these core and major related business courses. For the BS IT curriculum, IT courses comprise the core and the major-related requirements. In the BS IT program, however, the curriculum allows the student to study IT within the context of two carefully crafted IT concentration areas. The BS IT program will fill a niche that has resulted from the rapidly expanding body of knowledge that lies between existing disciplines such as CS and DMIS.

IV.1. BS IT Curriculum

The BS IT curriculum reflects the latest advances in the IT field, including interdisciplinary and global approaches where appropriate. An acceptable level of competency in IT can be achieved within the constraints of the 120 semester credit hours of class work and projects. This number of credits meets George Mason University requirements as well as the existing Commonwealth of Virginia guidelines for undergraduate degrees. Table 1 below provides the semester-by-semester curriculum for the BS IT major, including both University General Education (GE) requirements and other requirements for the BS IT degree. At least 30 semester hours toward the BS IT degree must be earned at George Mason University, and at least 45 semester hours of the degree requirements must be level 300 or above. Section IV.2 gives information on the structure of the BS IT program and Section IV.3 outlines the requirements for each of the concentration areas.

TABLE 1. BS IT DEGREE REQUIREMENTS

FIRST SEMESTER

IT 101	Introduction to Information Technology	3
IT 103 [GE]	Introduction to Computing	3
ENGL 101 [GE]	Composition	3
HIST 100 [GE]	Western Civilization	3
MATH 108 [GE]	Intro Calculus with Business Applications	3

SECOND SEMESTER

IT 108	Programming Fundamentals	3
IT 250	Introductory Statistics	3
Natural Science w. Lab [GE]		4
U. S. History [GE]		3
Literature [GE]		3

THIRD SEMESTER

IT 212	How Computers Work	3
IT 214	Data Base Fundamentals	3
MATH 125	Discrete Mathematics	3
Natural Science w. Lab [GE]		4
Social/Behavioral Science Elective [GE]		3

FOURTH SEMESTER

IT 213	Multimedia and Computer Graphics	3
IT 221	Introduction to Info Security Tech	3
COMM 100 [GE]	Oral Communication	3
Science w. Lab [GE]		3
Fine Arts Elec. [GE]		3

FIFTH SEMESTER

MSOM 302	Managing Information	3
MATH 111	Linear Mathematical Modeling	3
TCOM 300	Modern Telecommunications (derived from TCOM 500)	3
ENGL 302 [GE]	Advanced Composition	3
Elective		3

SIXTH SEMESTER

CS 305	Ethics and Law for Computing Professionals	3
MSOM 303	Marketing in a Digital World	3
IT Networking Core Course		3
IT Concentration Related Requirement		3
Elective		3

SEVENTH SEMESTER

IT 443	Resources Planning Requirement (New Course)	3
IT 4 91	IT Seminar (New Course)	1
IT 492 [GE]	Synthesis I (New Course)	3
IT Global Understanding Requirement [GE]		3
IT Concentration Related Requirement		3
IT Concentration Related Requirement		3

EIGHTH SEMESTER

IT 493 [GE]	Synthesis II (New Course)	3
IT Concentration Related Requirement		3
IT Concentration Related Requirement		3
Elective		3

IV.2. BS IT Program Structure

In addition to University General Education requirements, including humanities and social sciences as well as mathematics and basic sciences requirements, the BS IT program requires IT foundation, core, and concentration courses as described below.

1. IT Foundation Courses. All BS IT majors must complete the following foundation courses.

IT 101	Introduction to Information Technology (3)	
IT 103	Introduction to Computing (3)	
IT 108	Programming Fundamentals (3)	
IT 212	How Computers Work (3)	
IT 250	Introductory Statistics (3)	

2. IT Core Courses. All BS IT majors must complete the following core courses.

IT 213   Multimedia and Computer Graphics (3)
IT 214   Data Base Fundamentals (3)
IT 341   Network and Operating System Essential (3)
IT 451   IT Resource Planning (3)
IT 491   IT Seminar (1)
CS 305   Ethics and Law for the Computing Professional (3)
MSOM 302   Managing Information (3)
MSOM 303   Marketing in a Digital World (3)
TCOM 300   Introduction to Telecommunications {derived from TCOM 500} (3)

3. IT Capstone Design Project. All BS IT majors must complete a two- semester sequence of approved capstone design courses.

IT 492   Synthesis I {New Course} (3)
IT 493   Synthesis II {New Course} (3)

4. IT Concentration Courses. All BS IT majors must complete a total of at least 15 semester hours of IT concentration courses from the three categories of courses listed under the student's selected IT concentration area. The student must select at least one of these five courses from each of the three categories of courses listed under the selected concentration. The number of courses in each category will increase as the BS IT program matures. To ensure the integrity of the concentration, any substitution for a course in a specific category requires prior approval from the BS IT program coordinator.

IV.3. BS IT Concentration Areas

The jobs that BS IT majors are expected to fill focus on the application of IT in an increasing number of emerging sub-disciplines. Web development, computer graphics, information systems, telecommunication, network administration, and information security are a few of the sub-discipline areas frequently requested by undergraduates that are not available at George Mason University nor any other

university in the region. Key executives from the high technology industry predict large numbers of jobs of this type now and in the future and significant shortages of people trained to fill them effectively [12,16]. The new BS IT curriculum is sufficiently flexible to serve existing, emerging, and future IT educational needs while preserving the integrity of existing degree programs in more traditional disciplines such as Computer Science and Management Information Systems. This new BS IT curriculum serves a more diverse group of student and industry needs than do existing IT educational programs, and it is the model to be followed by other IT and engineering schools in order to cope with the rapidly changing needs of their high technology community.

There are two BS IT concentrations available:

A) Computer Graphics and Web Development
B) Information Security and Network Administration

A)   Computer Graphics and Web Development Concentration. Courses in the following three categories comprise the focus for this concentration: 1) Web development, 2) computer graphics, 3) database management. The student must select at least one of the five required courses from each of the three categories of courses listed under this concentration.

B)   Information Security and Network Administration Concentration. Courses in the following three categories comprise the focus for this concentration: 1) information security, 2) network administration, 3) telecommunications. The student must select at least one of the five required courses from each of the three categories of courses listed under this concentration.

IV.4.   Program Implementation

Many of the courses in the proposed BS IT curriculum already exist and are being taught within our Departments of Electrical and Computer Engineering; Computer Science; Information and Software Engineering; Applied and Engineering Statistics; Systems Engineering and Operations Research; and Civil, Environmental, and Infrastructure Engineering. Others are being taught within the College of Arts and Sciences, School of Management, and School of Public Policy. Additional courses will be developed over the first several years to broaden and strengthen the program as well as to meet the needs of the increasing enrollments that will be seeking a variety of existing and emerging IT career paths.

With the possible exception of a few 400-level courses, the two IT concentrations can be implemented with existing courses. This will enable us to establish the program and attract new students as early as fall 2002. In order to ensure that sufficient competence is obtained within a concentration, the traditional "free" approach to selection of electives has been replaced almost entirely by requiring the student to select from among pre-established electives associated with specific concentration areas. Since this is a minimal curriculum with an average of 15

credits/semester, this new BS IT degree program has greater flexibility than our other IT&E bachelor's degree programs, providing more opportunities for the highly motivated student to take additional courses, even if it is the student's goal to earn the BS IT degree in four years.

V. Challenges Encountered

In this section, we discuss briefly some of the major challenges that we faced throughout the various stages of the BS IT program development process. For example, some perceived the BS IT program to be a potential threat to enrollment in their programs, others perceived the BS IT program to be a softening of requirements relative to our other rigorous IT&E programs, while others questioned the extent to which the BS IT program would prepare students for life-long learning. As always, there were questions regarding the potential diversion of resources away from existing IT&E programs. As the BS IT program proposal neared maturity, it was generally the consensus that the new program will help achieve our goal, which is to produce more graduates who understand information technology and who can use it effectively.

V.1. Career Opportunities for Graduates

Lots of discussion centered on the degree to which the BS IT degree will enhance students' abilities to find work as IT professionals. The working group addressed these concerns by creating a curriculum containing two concentrations that emphasized six highly marketable areas of knowledge and skills. It was the consensus of the BS IT working committee that a deep technical understanding in some field is an important attribute for professionals to have, especially early on in their careers. Choices of skills to emphasize were based on informal conversations with former students, employers of community college students receiving the Associate's in Applied Science (AAS) degree, prospective employers, informal surveys of "help wanted" ads, and conversations regarding enrollments in IT electives and/or the popular IT minor.

V.2. Lack of Flexibility

One of the greatest challenges that we faced was arguing effectively that undergraduate IT education is not a concern solely of computer science or business departments. According to Dasigi [3], Information Technology (IT) can be divided into the following intellectual domains: Foundations of IT, Management of IT, Information Systems Technology, and Applications. Here at George Mason University, the Computer Science program tends to focus on the foundations of IT while our DMIS program has focused on the management of IT. Since few faculty at Mason in either CS or DMIS have demonstrated significant interest in issues related to Information Systems Technology and Applications, gaps clearly exist in these rapidly expanding area of IT. As a result, another program with a focus similar to our proposed BS IT program curriculum is clearly essential in order to keep pace with changing needs of industry, especially as they relate to the application of IT.

The Association for Computing Machinery (ACM) task force on the core of Computer science provides the following restrictive definition: "Computer Science is the systematic study of algorithmic processes - their theory, analysis, design, efficiency, implementation, and application - that describe and transform information" [5,11]. Additionally, recently proposed criteria for accrediting programs in information systems (IS) requires a minimum of 30 semester-hours of IS topics, 15 credits in business, 30 hours in general education and 9 hours in quantitative and qualitative analysis [6,7]. For example, in our Management Information Systems (DMIS) major (managed by the SOM here at Mason), all students must take courses in business areas such as management, accounting, marketing, and finance. As a result, neither the CS nor DMIS program offers the flexibility needed to accommodate the emerging body of IT knowledge.

V.3. Accreditation Requirements
The proposed BS IT program is structured in a manner that is very similar to that of our other IT&E programs to ensure proper balance of degree requirements in general education and major related requirements. The decision was made early on not to allow accreditation criteria for disciplines such as CS and IT to unduly constrain the overall design of the BS IT major. Initial measures of success will include factors such as student and course evaluation results, faculty evaluation of the quality of students attracted to the programs, graduate school acceptances, employment offers and consequent successes. It turns out, however, that the BS IT program will meet SACS accreditation criteria. Since accreditation criteria for other disciplines have changed from pure formulas dictating course mixes to self-directed programs with clear objectives, performance-based assessments, and constant feedback and planning [5], the BS IT program is likely to be looked upon favorably by an appropriate board that might review BS IT programs in the future.

V.4. Credibility as an IT&E Program
As has been traditionally the case with university computer science and engineering programs, all of our existing School of IT&E undergraduate programs have rigorous mathematics and natural science requirements in areas such as physics and computer science. The most frequently stated reason for CS faculty resistance to the BS IT program was centered around "math phobic" related concerns, even though there tends to be a huge disconnect between the mathematics requirements and the actual use of mathematics in other required courses as well as in the IT field of practice [1,15]. Even though the BS IT program curriculum has less rigorous mathematics, science, and computer science requirements, a collection of mathematics, science, and computer science related courses have been carefully crafted to ensure continued development of the student's problem solving skills as well as mathematical maturity essential for reading the literature in the IT field. Our aim is to ensue that the BS IT program is not perceived as a softening or dumbing down of our IT&E programs, potentially resulting in a massive switch from other IT&E majors into the BS IT major.

V.5. Potential Impact on Existing Programs

Instituting the BS IT major will lessen the pressure on both CS and DMIS programs to broaden the content of their curricula [8,10]. Some likely effects of the new BS IT major on the CS and DMIS programs include the following: a decrease in the number, but an increase in the overall quality, of students who enter the CS and DMIS majors; an increased accessibility of IT educational programs for students who do not love mathematics; the increased competition for scarce resources. We hope to address these concerns by maintaining high standards for IT courses; by limiting enrollments, should promised resources fail to become available; and by having tenure track faculty routinely teach courses in both the BS IT program and other IT&E programs.

V.6. Establishing Boundaries

Establishing the boundaries and appropriately defining IT as a "discipline" proved to be one of our greatest challenges [4,11]. Getting faculty with diverse backgrounds from diverse departments and institutions to agree on a limited set of intellectual skills that all students need to develop is a formidable endeavor. Determining what kind of students should be enrolled in the BS IT program and what these students should be able to do upon graduation seemed to be almost insurmountable tasks. However, they were essential first steps to establishing the admissions standards, which set the tone for the content and of the BS IT curriculum.

VI. Conclusions

This paper has addressed issues related to the new BS IT program within the context of IT workforce needs. We defined a new degree program and established two concentration areas within that new degree program. The proposed BS IT curriculum combines major related requirements with general education requirements and electives to prepare students for professional employment in the information technology workforce, for further study in information technology, and for other careers requiring competencies in IT. The BS IT program fills the gap in our current program offerings without adversely affecting the quality of our strong academic programs in computer science and MIS.

The BS IT program is not a restructuring of an existing program, but rather a new program that enables us to maintain the integrity of existing disciplines such as CS and DMIS while preparing IT professionals who are well suited to the needs of the rapidly changing high technology economy and its knowledge domain. The new curriculum for the BS IT program will include knowledge from existing curricula that is properly adapted to the needs of the BS IT majors, as well as new knowledge specific to IT professionals.

Our BS IT program is justified as a separate GMU degree program for several reasons:

1. Although one may be able to take several IT classes as part of one of our existing IT&E or SOM degree programs, it is not possible to acquire a sufficient body of IT knowledge and skills relevant to a growing number of emerging IT-related discipline areas without exceeding greatly the existing program's 120 semester hours requirement.

2. IT is becoming a recognized discipline in its own right as is evidenced by the number of universities (e.g., Rensselaer Polytechnic Institute (RPI), Purdue, etc.) throughout the nation that are starting programs at the undergraduate level.

3. There is a demonstrated need in the Northern Virginia workforce for professional employees with the knowledge and skills that will be acquired by the students who graduate with a BS IT degree.

This new undergraduate program is perfectly suited for the student who does not enter with a formal training in computing as well as for the student who might not have a love for theoretical aspects of the mathematical and natural sciences. The jobs that IT majors are expected to fill focus on the application of computer and communication technologies in other disciplines.

The new BS IT curriculum is sufficiently flexible to serve existing, emerging, and future IT educational needs while preserving the integrity of existing degree programs in disciplines such as computer science and management information systems. This new IT curriculum serves a wider variety of student and industry needs than do existing programs.

The new BS IT major should meet the needs of students and employers while improving retention and increasing enrollment. Preliminary indications suggest that the BS IT degree will become the program of choice among IT&E majors.

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