Developing a Software Engineering Technology Program

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Abstract

The Department of Engineering Technology and Multimedia Design (ETMD) within the School of Computing and Engineering Sciences at Eastern Washington University is developing a new program in the emerging discipline of Software Engineering Technology (SET). It was conceived on the basis of three major factors: industrial demand within the region and state, the small number of qualified graduates available to enter the workforce, and the increasing pool of potential students. Some of the projected activities in the planning process include visiting nation-wide university campuses that currently have SET programs, identifying new laboratory equipment needs, setting up an advisory board, creating a recruitment plan, and obtaining ABET accreditation. This paper will document this planning process.

Funds from the National Science Foundation (NSF), in form of a recently approved grant proposal, will facilitate the planning process for this program. Some of the components of the curriculum design to be developed will include integrating new learning strategies and problem solving techniques, obtaining an active role of regional industry, and creating aggressive non-traditional student recruitment and retention plans.

The incipient construction of a new building to host the recently formed School of Computing and Engineering Sciences will provide a state-of-the-art facility to house the SET program. The new building has been designed keeping in mind the space requirements for laboratories for the SET program.

The ETMD Department's close ties with the Computer Science Department, and the new building extended facilities, will provide the necessary infrastructure and human resources to offer a Cyber-security option. This option is consistent with the current research and academic trends in national security.

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1. Introduction

Software related fields are growing rapidly [1, 2, 3, 4]. In May 1999, the Washington Council of the American Electronics Association (AEA) formed a Higher Education Task Force which undertook a study revealing that within three years Washington State would need an additional 40,000 positions requiring technology degrees, training or certification [5]. The report concluded that the need is especially acute in engineering, computer science, informational systems and related technology fields. Based on these alarming numbers, the AEA task force advised that "state colleges and universities must increase capacity and improve access for would-be students" and that "Washington State's Governor Locke and the legislature should focus on funding new capacity in higher education."

Eastern Washington University (EWU), one of three comprehensive regional universities in the State of Washington, saw itself in the unique position of being poised to meet the demands of industry, follow the recommendations of the AEA task force, and provide the additional capacity called for by the Higher Education Coordinating Board and Governor Locke. Thus in 2000, the College of Science, Mathematics and Technology at EWU began a process of reorganizing and redeveloping the programs in its Departments of Engineering Technology and Multimedia Design, Computer Science and Physics in response to the current workforce needs particularly as they applied to the regional technology sector. To this end, the faculties of these departments united within a new academic unit named the School of Computing and Engineering Sciences where interdependent programs can focus on student learning within the context of the ever-increasing demand for technology connected degrees. Seeing the benefit of a new academic unit at EWU, the Washington State legislature has now funded the design of a new state-of-the-art building to house the school and its programs.

One of the core program goals of the new school is an ABET accredited program in software engineering technology (SET), an inter-engineering program, to be developed under the leadership of the Department of Engineering Technology and Multimedia Design. The development of the SET program at Eastern Washington University is consistent with the National Science Foundation's charge to develop new curricula for emerging engineering disciplines at the undergraduate level and meet the emerging workforce and educational needs of US industry. Funds from NSF, in form of a curriculum development grant, are facilitating the planning process for this program and allowing for thoughtful consideration and thorough evaluation of both curriculum and laboratory needs and enrollment and retention strategies.

The SET program will emphasize the application of engineering principles to the solution of practical problems within the contexts of understanding, developing, operating and maintaining software and software intensive systems. The program will bridge software and hardware technologies by establishing a close alignment with computer science. To this end, students who graduate with a Bachelor of Science in SET will enter the workforce as software engineering technologists, system engineers, system analysts, and programmer/analysts. The planned inclusion of sufficient engineering management and economics principles in the curriculum will also prepare graduates to obtain positions in project management.

The SET program is being designed in line with the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET) program guidelines [6]. Graduates of this type of program are currently in great demand and obtain jobs with engineering firms, consulting agencies, governmental agencies, and manufacturing facilities where they work with engineers and computer programmers to optimize computer procedures and processes for many types of engineering projects. While typically engineers design systems and processes and programmers produce software, there is also a need to interface engineering projects with software controls to avoid the gap created by the current separation of these processes. The software engineering technologist would bridge this gap, as he/she learns the fundamentals of engineering design as well as software engineering.

Consider, for example, the automated equipment used in a factory that produces cans where a set of rollers is used to move a billet of aluminum through the processing area. These rollers must be able to adjust their separation distance and speed of rotation in unison with a laser sheet thickness-measuring device that is coupled with aluminum sheet temperature sensors. This system is then combined together through an A/D converter for converting analog to digital signals for computer access, switching devices, and logic programmers to provide proper interfaces with computers. Then a software program in C or C++ is used to control the entire system. Finally, the process is interfaced with a website through multimedia software. A SET graduate of EWU will have the knowledge and skills to undertake the design and implementation of such a process.

2. Infrastructure Development

The doors to the school's new facility, housing 15 classrooms (two of which will be wired for distance education) and 21 laboratories, with many spaces designed for interaction and collaboration between departments, will open in 2004/2005. With more space (93,000 gross square feet and 60,000 assignable square feet), Eastern can serve 78% more students in the Department of Engineering Technology and Multimedia Design, increase enrollment by 21% in Computer Science, and serve 28% more students in Physics. With an eye toward the future, the new facility has been designed to accommodate students and faculty based on projections for enrollment in 2010. Laboratories will be furnished with the latest equipment giving students the opportunities they need to understand and use these technologies as professionals. Specialized labs and equipment will also help faculty further their research and foster industry partnerships, with the goal of leading to new technologies and new applications for current technology. (Additional information on the new facility and the programs of EWU's School of Computing and Engineering Sciences can be found at http://www.ewu.edu/newtech/.)

3. Significance of the SET Program

The SET program within the School of Computing and Engineering Sciences was conceived largely on the basis of three major factors: industrial demand within the region and state, the small number of qualified graduates available to enter the workforce, and the increasing pool of

potential students as a result of the economic downturn. It is Eastern Washington University's goal to develop and offer a timely and high-quality SET program that provides a thorough understanding of theory and design combined with the variety of practical skills needed today.

EWU's service area is principally the Inland Northwest, a vast region encompassing eastern Washington, northern Idaho, western Montana, eastern Oregon, and southern British Columbia. This area offers a highly educated workforce, a low cost of living and of doing business, exceptional technology and communications infrastructure and extensive resources in higher education, research, and health care. What the region lacks is a critical mass of professionals trained to fill the current needs of high-tech business and industry—a shortage that is felt nationally. No SET programs currently exist in the region or within the state.

The State of Washington has recently experienced a significant downturn in its economy caused by a worsening recession and a significant downsizing in 2001 of a number of companies, particularly those in the aerospace and high technology industries. In higher education, the fallout from this stressed economy will be more individuals seeking to go to college. These anticipated increased enrollments coupled with the workforce demographics provide a compelling argument for Eastern Washington University to bring its new state of the art Software Engineering Technology program to fruition.

4. Work Plan

A new curriculum will be developed in the emerging discipline of Software Engineering Technology as part of the department- and school-level reform being undertaken at Eastern Washington University. SET will initially be set as an option for the ABET-accredited program currently at EWU. Faculty in the Department of Engineering Technology and Multimedia Design have already developed a preliminary, freshman- through senior-year curriculum outline for the SET program (Appendix A). As currently envisioned, this curriculum is based on a series of existing lower division prerequisite courses in mathematics, English, physics, and general education requirements. The upper division core includes both existing courses and proposed new courses and laboratory revisions in engineering technology and multimedia design and computer science. The physics labs, PHYS 161 (mechanics), PHYS 162 (heat and optics), and PHYS 163 (instrumentation I), required during the second year of the program are currently undergoing redevelopment. These revisions are being accomplished through a congressional grant provided (through the US Department of Education) to the School of Computing and Engineering Sciences, in part, to enhance the foundational learning necessary to succeed in the new SET program. This grant also is supporting the development of cyber-security content and coursework to be integrated into the SET program as well as other program areas.

For the specific purposes of this NSF planning grant, five principal objectives to be met within a 12-month period have been developed for the project:

(1) Design SET coursework and identify program requirements within the frameworks of student mentoring, team-based learning, internships, industry assistance, problems from industry, and experience-based learning.
(2) Identify new laboratory and equipment needs and revisions to existing laboratories.

(3) Develop student recruitment and retention procedures including strategies to increase the participation of minority and women students.
(4) Increase advisory board membership and improve participation and meaningful dialogue on the program.
(5) Develop a timeline for completing curriculum development, seeking department, school, advisory board, university, and state approval and obtaining ABET accreditation.

4.1 Project Activities

Objective 1: SET Coursework

Under the current program model nine SET courses remain to be developed or revised. These include ENGR 250 (Digital Circuits II), CSCD 350 (Software Design I), CSCD 440 (Operating Systems), TECH 377 (Microprocessors II), TECH 416 (Data Communications), TECH 490 (Senior Capstone), TECH 491 (Senior Development Project), CSCD 451 (Software Design II), and TECH 417 (Network Security).

Prior to any development of the curriculum, two curriculum research and planning activities will be completed. The first is to conduct a survey of at least 10 schools operating ABET-accredited software engineering technology degree (or closely related) programs to gain useful program information. The survey will ask questions about curriculum and pedagogy; texts and materials used; laboratory facilities, manuals, and exercises; student enrollment and retention demographics and strategies; faculty qualifications and expertise; and articulations with area and regional community colleges and technology companies. The second activity involves project faculty visits to two SET programs at peer institutions, such as the University of Southern Mississippi, Arizona State University, and the Oregon Institute of Technology. The visits are geared toward obtaining more in-depth information on curriculum goals, laboratory configuration, facilities, administrative functions, and student outcomes in their Bachelors of Science programs.

Information derived from the surveys and obtained during the site visits will be evaluated and synthesized by the planning team and used to both validate EWU's proposed SET coursework and guide the future development of curriculum and laboratories.

The program design must meet the TAC of ABET criteria. All curriculum planning, including the identification of program objectives and outcomes, will be conducted with this final goal in mind.

A third component of the activities under Objective 1 will be an evaluation of new or updated learning strategies and problem-solving techniques and the development of recommendations for integrating these strategies and techniques in the curriculum. Brief descriptions of those under consideration include the following.

Mentoring Appropriate local representatives will be identified by the planning team (with the assistance of the advisory board) to serve as mentors to SET students with regard to career opportunities and senior projects. A list of mentors with professional background descriptions will be created during the planning process. Once the SET curriculum is implemented, students will be provided the opportunity to work with mentors on special projects subject to the approval

of a faculty member to ensure that the scope and the level of difficulty of the project are commensurate to the class needs. This mentoring approach is similar to what is currently in place in the other programs in the Department of Engineering Technology and Multimedia Design at EWU.

Team-based learning Current trends in the field of technology indicate that team based projects are increasingly more beneficial to the learning experience than individual ones [3]. Because software engineering technologists often work as a member of a team in their profession, especially when engineering processes interface with software processes, the department will explore the possibility of developing multi-disciplinary, problem-oriented team projects. This approach will allow students from different programs and departments to work together on projects which simulate real working environment scenarios. Group projects and assignments will be stressed throughout the program, which will culminate with a team senior project and capstone design class.

Internships Working closely with local and regional industry in the development of the SET program, the planning team will identify a new pool of internship positions for students in the SET program. Students completing internships through these businesses will obtain practical experience and credit toward their academic degree, while opening the door for future permanent employment.

Direct involvement of industry Industrial representatives will be given the opportunity to provide input into the development of curriculum and laboratories through an employer survey. An objective of this survey will be to identify current and cutting-edge trends and related workforce preparation needs. The planning team will also tour a sample of representative SET-related businesses in the local area and interview personnel to gather additional data on the current skill sets required in the SET work environment.

Assign industry problems to students Industry partners will be presented with the opportunity of having various SET classes (faculty and students) tackle real problems on their behalf through the survey and personal contacts identified above. Area technology companies may propose projects or assignments with an expected outcome to the Department of Engineering Technology and Multimedia Design. Faculty will evaluate the proposal for compatibility with the curriculum, to ensuring it provides a meaningful problem-solving approach to learning, and for its potential for a favorable outcome within a reasonable timeframe with students in the program. Once a proposal is accepted, an appropriate representative from the company must commit time to the project at the university, serve as a mentor, member of the advisory board, or guest lecturer, oversee an internship, or participate in some other role that contributes to the SET program. These assignments are expected to encompass a wide variety of industry-related theoretical and practical problems.

Laboratory-oriented experience-based learning An intrinsic difference between software engineering and SET is the amount of laboratory experience the student will be expected to participate in throughout the program. The SET program will stress laboratory-oriented learning, while not straying off the theoretical background necessary to understand the systems at hand.

The laboratory experience at Eastern Washington University will be thorough and comprehensive. New and existing labs will be created in the new facility that will house the School of Computing and Engineering Sciences.

Objective 2: SET Laboratory Needs

The SET program is currently envisioned with a laboratory-intensive curriculum. During the planning phase considerable effort will be devoted to designing laboratories and selecting equipment. Laboratories currently proposed for the program include Circuits, Computer Architecture, Software Design, Digital Logic, Network Security, Senior Project, Microprocessor, Embedded Systems, Programmable Logic Controllers, and Senior Capstone. Based on information gained from other undergraduate SET programs and industry consultations, the planning team will refine the list of laboratory needs by identifying equipment, lab configuration, and ideal numbers of workstations and by suggesting appropriate experiments and projects. These needs will be reflected in the overall curriculum design for the program.

Objective 3: Recruitment and Retention of Nontraditional Students

A recruiting and retention plan will be developed as part of the new curriculum design. The development of this plan is considered to be a crucial and fundamental component of the overall SET program development. Most certainly one of the biggest concerns of EWU, the school, and the department is the recruitment and retention of underrepresented groups in the technology program.

The activities to be undertaken toward the development of a plan include:

- Identification of best practices undertaken at other institutions of higher education offering programs in SET,
- Identification of industry mentors and culturally relevant internships for nontraditional students (i.e., minority owned businesses, businesses located in the students home community),
- Identification of employers sensitive to the needs of nontraditional students (i.e., flexible hours, daycare center on site, diverse workforce),
- Articulation with the university's McNair Scholars program to support at least one SET student per year in their matriculation to graduate school,
- Formal recommendation for faculty development plans (required for tenure and promotion) where faculty get credit for mentoring and retaining nontraditional students in the SET program,
- Identification of scholarship and fellowship opportunities in the engineering sciences for nontraditional students,
- Consultation with the National Action Council for Minorities in Engineering and other organizations ensuring the participation of minorities and women in engineering fields, and
- Outreach to K-12 schools and organizations supporting the educational development of nontraditional students.

The planning team will work closely with the African American Studies, American Indian Studies, Chicano Education, and Women's Studies programs at Eastern where successful recruitment and

retention programs already exist as well as the newly formed university Diversity Committee. The Diversity Committee is currently working on developing an institutional wide plan to enhance and increase the level of support and services provided to nontraditional faculty and students at the university. As appropriate, findings and recommendations offered by this committee and the ethnic and Women's Studies programs will be used along with the specific activities identified above to make this new curriculum a success.

Objective 4: Increase and Improve Advisory Board Participation
The final design of the SET program will be created with the direct involvement of the department's Advisory Board to ensure that the curriculum and other program components are in line with cutting edge developments in industry and are responsive to the needs of prospective employers. To this end, part of the efforts under this planning grant will be to expand the existing advisory board to include additional SET members and non-technical members such as representatives of area K-12 school districts; the Mathematics, the Engineering and Science Achievement Program and the Latino/Latina Educational Assistance Program. The current advisory board includes alumni, faculty from other universities, and industrial representatives. Each member is expected to actively participate in the decision-making process surrounding SET program development by providing advice and counsel on emerging trends in the industrial community. Its members are involved in the curriculum development of departmental programs, internship creations, and other types of advice. The participation will be expanded under this planning project to aid the department in creating a viable student recruitment and retention plan as well as to help inform the department on SET curriculum matters.

Objective 5: Develop a Timeline for Required Approvals Before the implementation of the SET program design, the curriculum must be approved by the departments of Engineering Technology and Multimedia Design and Computer Science, the departmental Advisory Board, the School of Computer and Engineering Sciences, the College of Science, Mathematics, and Technology, the EWU undergraduate affairs council of the faculty senate, and possibly the Washington State Higher Education Coordinating Board. This approval process will be undertaken upon the finalization of the SET program design and this planning project will be used to establish a timeline for obtaining the required approvals.

4.2 Project Outcomes
A final curriculum design will be completed during a 12 month period. It will be prepared both in a written report and presented on the Department of Engineering Technology and Multimedia Design website. The principal components of the curriculum design to be developed under this grant include:

- A synthesis of research derived from surveys and site visits to industry and other undergraduate SET programs,
- Program objectives and outcomes based on the research and internal discussions within the department, school and college,
- A final list of proposed SET courses including course descriptions based on the research,
- Recommendations for integrating new learning strategies and problem-solving techniques in the curriculum,

- An identification of potential industry mentors, internships, and industry-originated classroom projects,
- A final list of laboratory needs including identification of equipment, configurations, and numbers of workstations,
- A student recruitment and retention plan that focuses on nontraditional students,
- Increased advisory board membership to include persons with a background in SET and non-technical members who can assist with both curriculum development and student recruitment and retention,
- A timeline for obtaining final program approval, and
- A checklist of TAC of ABET requirements

5. Future Plans

The new SET program at Eastern Washington University has a well-stated long-term plan leading from the planning period to the implementation phase. Implementation will consist of developing the curriculum for new courses, piloting of courses and new learning strategies and problem-solving techniques, the purchasing of laboratory equipment, and implementing student recruitment and retention activities, beginning no later than 2003. While the existing complement of technology and computer science faculty are capable of both developing and offering the new program in its initial stages, a steady increase in the number of students is expected. As the student population rises and the program expands and is institutionalized in the new facility, it is planned that at least two new faculty members will be added to the department.

Another component suggested for the future and in the new facility is the increase in collaboration with industry where the department will explore partnering with businesses to allow experienced engineers to spend a sabbatical year in EWU. The partnership could include reciprocal exchanges, where the faculty at Eastern Washington University would spend time in industry to promote technology transfer and other collaborative research between academia and industry. To this, and other ends, the new program in SET at Eastern Washington University will have a cutting-edge culture, with a commitment towards keeping up with advances in SET practice and education.

Appendix A

Freshman Year

Course Number	Title	Credits
MATH 106	Pre-Calculus II	5
MATH 161	Calculus I	5
ENGL 101	English Composition I	5
ENGL 201	English Composition II	5
GECR	General Education Core Requirements	15
ENGR 160	Digital Circuit I	3
CSCD 225	Programming Principles I	5
CSCD 205	Programming Principles I Laboratory	1
Total		49

Sophomore Year

Course Number	Title	Credits
MATH 162	Calculus II	5
PHYS 151	Physics I	4
PHYS 161	Physics I Laboratory	1
PHYS 152	Physics II	4
PHYS 162	Physics II Laboratory	1
PHYS 153	Physics III	4
PHYS 163	Physics III Laboratory	1
ENGR 250	Digital Circuit II	2
ENGL 205	Technical Report Writing	5
GECR	General Education Core Requirements	5
CSCD 226	Programming Principles II	5
CMST 200	Communication Studies	4
TECH 276	Microprocessors I	4
Total		45

Junior Year

Course Number	Title	Credits
CSCD 208	Unix Laboratory	1
CSCD 228	Unix	2
CSCD 229	C Programming Language	3
CSCD 326	Data Structures I	4
CSCD 333	Intro. Computer Networks	4
CSCD 350	Software Design I	4
CSCD 351	Software Design I (lab)	1
TECH 498	Engineering Economics	4
CSCD 425	Databases	4
	Technical Elective	4
TECH 377	Microprocessors II	4
	Elective	7
GECR		5
Total		47

Senior Year

Course Number	Title	Credits
TECH 403	Project Management	4
TECH 416	Data Communications	4
TECH 425	Computer Arch. And Design	4
TECH 490	Sr. Capstone	4
TECH 491	Sr. Development Project	6
	Technical Elective	8
CSCD 450	Software Engineering I	4
CSCD 451	Software Engineering II	4
TECH 417	Cyber Security	5
	Elective	5
Total		48

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Biographical Information

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