

Senior Design Project: ABET 2000 Certification

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Abstract - The senior design course sequence SYST 490/495 at George Mason University (GMU) is designed to give Systems Engineering students hands-on experience in applying the methods taught in the Systems Engineering Undergraduate degree.

The 1998 - 1999 Systems Engineering Senior Design class project was to create a system to aid the Systems Engineering Operations Research (SEOR) Department in the preparation for ABET 2000 certification of the Systems Engineering Undergraduate degree. The purpose of the project is:

- ◆ To provide Systems Engineering seniors with hands-on experience in applying the systems engineering process to the problem of developing and maintaining a real-world system;
- ◆ To provide Systems Engineering seniors with hands-on experience in interacting with clients to understand their needs and develop solutions that meet the clients' needs;
- ◆ To provide the SEOR department at GMU with an ABET2000 program evaluation process.

This paper will document the process the students and the professor went through in developing a viable system to help in this endeavor. There were 11 students in the class and the work has just been completed. During the first semester, the students evaluated products from the last accreditation, researched the differences in requirements between the last one and the Year 2000 accreditation, reviewed what other universities had done to meet requirements, and developed a Systems Requirements Specification documenting those requirements necessary to meet accreditation. In the second semester, they completed the design, implementation and testing process for capturing program educational objectives (ABET criterion 2) and program outcomes and assessment (ABET criterion 3) via a Web-based application. The system they developed, the Program Evaluation Process (PEP), works as specified by the requirements and was very well received by the faculty. PEP is being used in the GMU SEOR department to augment efforts to meet ABET 2000 requirements.

Introduction

The senior design course sequence SYST 490/495 is traditionally taught in the final two semesters of a student's curriculum and is the capstone sequence of the Systems Engineering Undergraduate degree at George Mason University (GMU). At the beginning of the first semester,

the professor gives the students a statement of work (SOW) for a project that is to be completed by the end of the year. This project is to develop a system using the life cycle concepts learned during the degree. In a survey conducted by the United States Military Academy with students that had completed the capstone course in engineering, the students indicated that team ownership of a project; inspired by appropriate mentorship is the most significant factor in providing students an optimal experience [1]. This conclusion supports the findings of the Systems Engineering Operations Research (SEOR) Department at GMU. The professors that have taught the course have had years of practical experience implementing systems, which they are able to share with the students.

The 1998 - 1999 Systems Engineering Senior Design class project is to create a system to aid the SEOR department in the preparation for ABET 2000 certification of the Systems Engineering Undergraduate degree. For this project, the students were given a SOW that contained the following requirements to be performed:

- ◆ Study ABET 2000 for program evaluation guidelines;
- ◆ Study the SEOR department's current program evaluation process and identify areas of needed improvement;
- ◆ Examine the program evaluation processes of other George Mason University, School of Information Technology and Engineering (ITE) departments, including changes being instituted for ABET 2000;
- ◆ Develop and maintain a data repository of information pertaining to ABET2000;
- ◆ Design a new process for the SEOR department based on their needs evaluation;
- ◆ Document the new process;
- ◆ Design and develop computerized support as needed for administering the revised process;
- ◆ Educate the faculty about the new process;
- ◆ Institute some aspects of the new process in the Spring of 1999;
- ◆ Monitor and evaluate the changes that have been implemented;
- ◆ Recommend additional adjustments based on their evaluation

Research Component

The Accreditation Board for Engineering and Technology (ABET) is recognized in the United States as the sole agency responsible for monitoring, evaluating, and certifying the

quality of engineering, engineering technology, and engineering-related education in colleges and universities. [2]. Any institution seeking accreditation of an engineering program has to demonstrate that the program in question clearly meets certain criteria, as determined by ABET.

The challenge facing the Student Design Team (SDT) was to determine the differences between the previous SEOR ABET accreditation process and the new one. This demanded detailed research and careful analysis of the last process. In the first semester, the SDT split into several groups in order to gather requirements efficiently and without waste of limited resources. The purpose of the first semester was to expose the students to the beginning phases of the systems engineering life cycle. During this time, they conducted both problem analysis and product description as part of the requirements engineering phase of the life cycle. Doing a better job of defining and specifying software is not only worthwhile but also possible and cost effective [3]. Therefore more time was devoted to this activity. The students discovered the difficulty of understanding a problem, and then being able to transform that problem into a documented description of the required product.

The requirements research included looking at the processes that Systems Engineering departments in other schools went through to receive ABET 2000 accreditation, as well as the process that the SEOR department had gone through in order to receive their previous accreditation. Material that was presented to ABET in 1995 was obtained, and members of the faculty were interviewed who participated in the last accreditation process. Upon review of material and interviews, the SDT was able to define the differences between the ABET 1995 and the ABET 2000 requirements. The major difference is the addition of two new criteria referred to as, 'Criterion 2 and Criterion 3' in the list of ABET 2000 requirements.

Criterion 2 is 'Program Educational Objectives'. This criterion requires that any engineering institution seeking accreditation or reaccreditation must have in place:

- detailed published educational objectives that are consistent with the mission of the institution and these criteria
- a process based on the needs of the program's various constituencies in which the objectives of are determined and periodically evaluated
- a curriculum and process that ensures the achievement of these objectives
- a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

Criterion 3, 'Program Outcomes and Assessment' states that engineering programs must demonstrate that their graduates have:

- an ability to apply knowledge of mathematics, science and engineering
- an ability to design and conduct experiments, as well as

- to analyze and interpret data
- an ability to design a system, component or process to meet desired needs
- an ability to function on multi-disciplinary teams
- an ability to identify, formulate and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global and societal context
- a recognition of the need for and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use techniques, skills and modern engineering tools necessary for engineering practice.

These new criteria formed the basis for the recommended changes needed to the old process in order to meet the new ABET requirements. The SDT gave a formal presentation at the end of the Fall semester to the SEOR faculty, invited faculty from other departments and the ITE Undergraduate Dean. At this presentation, they included a detailed explanation of their problem analysis methodology as well as the requirements they felt were needed to ensure ABET 2000 compliance. They also reviewed the System Requirements Specification they had produced to document those requirements.

In order to meet Criterion 2, the SDT suggested:

- 1) Revision of the SEOR Mission Statement, and corresponding educational objectives of the SEOR department. The SDT suggested a new SEOR Mission Statement, a few modifications to the previous list of program objectives, as well as the addition of a few new objectives. This proposal was accepted and adopted by the faculty.
- 2) Mapping of the SEOR undergraduate curriculum to the new SE program objectives and periodic review to ensure compliance between the curriculum and the objectives
- 3) A process of periodic evaluation of the entire SE program was designed by the SDT and proposed as a means to formalize an already ongoing, but so far informal process of evaluation of the program.

In order to meet criterion 3, the SDT suggested:

- 1) A list of program outcomes be developed. The SDT proposed a list of 12 possible program outcomes.
- 2) A process of evaluation whereby the program outcomes, program curriculum and program objectives are continually analyzed in order to ensure their consistency with the department's Mission Statement, and with one another.

The research conducted by the SDT concluded that the SEOR department met the ABET 2000 requirements except for the two new criteria. To fulfill the first semester

requirements, the SDT proposed the development of a Program Evaluation Process (PEP) documented in the Systems Requirements Specification (SRS) for the systems engineering undergraduate program in order to successfully meet the new criteria of the ABET 2000 accreditation. The Spring semester involved the design, implementation and testing of the PEP system.

The Program Evaluation Process (PEP)

The students were very careful to delineate the boundary of the system they proposed. The objective of the PEP is to assist the SEOR department in meeting only criteria 2 and 3 of the ABET 2000 requirements for their systems engineering undergraduate program.

The PEP enables the SEOR department to demonstrate to ABET an ongoing process of evaluation and assessment of the SE undergraduate degree in accordance with the department's Mission Statement and objectives.

PEP consists of five major Items that will all aid in the evaluation process:

Item A: Process Model & Timeline

The major part of the new accreditation effort for the SEOR department is to formalize the process to be undertaken to achieve accreditation. To meet a primary objective of ABET, the department has to ensure that the process they follow is 'ongoing' and will continue even after accreditation for the year 2000.

The SDT designed a formal ongoing process for the SEOR department to use to meet primarily criteria 2 and 3 of the ABET 2000 requirements. As part of this process, the SDT identified the major tasks and responsibilities of SEOR department for the accreditation process and program evaluation activities. The SDT formulated effective schedules, suggested appropriate measures for specific tasks and provided a timeline of evaluation activities for a five-year period reflecting the ongoing process.

Item B: Project Presentation Evaluation Form

One of the objectives of the department is that students be able to communicate effectively both orally and in written form. To aid in this objective and to ensure a consistent application of evaluation, a project presentation evaluation form was designed to aid instructors in evaluating student presentations. The evaluation form was designed for individual and group projects. An instructor will write the name(s) of the student(s) presenting at the top of the form. The instructors will then complete the form by grading the student(s) based on specific abilities such as communication skills and presentation content. After the instructor has completed all forms for the entire class, the forms will be given to the administrative personnel. The administrative personnel are then responsible for inputting the necessary information into a computerized database for the purpose of

generating reports. Reports will be generated and made accessible to the department. These reports will be used to analyze the effectiveness of student presentations and to determine if the given objective is being met.

Item C: Student Effectiveness Scores Form

The ABET specified Criteria 2 and 3 require that the engineering institution seeking accreditation show that the program objectives and outcomes are being met by the program curriculum. Both criteria also demand that a process be established, by which the program objectives, outcomes and curriculum are periodically evaluated and improved based on the results of the evaluation.

In order to meet the requirements for this task, the SDT, using the recently revised SEUG program objectives and curriculum, devised a means for measuring the effectiveness of the SEUG program.

The SDT mapped the program curriculum to the objectives and outcomes of the program. This enables the faculty to ensure that every objective and outcome is being met by some part of the program curriculum.

The SDT mapped the core systems engineering courses to the program objectives and outcomes. This shows that within the core classes, the SEUG is able to meet all its program objectives.

For each core systems engineering course the professor teaching the course has developed a set of objectives. The SDT developed a sample course evaluation form, which will be used to evaluate how well the students meet the specified objectives of the course.

Having established this relationship, the SDT developed an Effectiveness Scores Form which will be used to analyze just how well the department is able to meet its defined objectives. This will satisfy the 'ongoing process' requirement of ABET because the results of the evaluation of the program objective and outcomes using this form will be used to improve the SEUG program. The form will show a mapping of:

- The core systems courses to the program objectives
- The course objectives to the core systems courses
- The performance of the students in meeting the individual course objectives, and in turn, the program objectives.

It is the results of the students' performance that will be used in evaluating effectiveness of the courses in meeting the Program objectives.

Item D: Alumni Survey

The Alumni Survey Form was designed to solicit feedback from the SEOR alumni to gain insight about the negative and positive aspects of the undergraduate program. Administrative personnel will be responsible for mailing the alumni survey forms to alumni periodically. The alumni survey form consists of questions addressing each departmental objective and the overall impact the systems

engineering program had on the individual's success in the systems engineering field. There is also a section at the end of the survey that allows alumni to provide any additional comments or concerns they would like to express that were not addressed in previous questions. After completing the form, alumni mail the survey form back to the SEOR department office. Once administrative personnel receive the survey form, they will input the necessary information into a database for the purpose of generating reports. The reports will be generated and made accessible to the department. As part of the testing cycle for this item, the SDT called past alumni and filled in the forms to gather feedback for the faculty. They then entered the forms into the PEP system. The exercise was very valuable in that information regarding the benefits of certain classes taught to the alumni as they related to the alumni's current employment was very enlightening. The SDT was able to generate a report out to the PEP system with the analysis of alumni response for the SEOR faculty.

Item E: Computerized Support

SDT developed a relational database to log and analyze information obtained from the various forms required in items A through D above. The PEP database also was developed to support the other requirements contained within the SRS. These included the migration of the undergraduate records that had been maintained on an Excel worksheet into the database and the development of a countdown calendar to the ABET 2000 visit to be used by SEOR faculty. Administrative support personnel were trained by the SDT in the use of PEP and the maintenance of

the database in the future. They will be responsible for generating forms as requested by the faculty, inputting the information from the evaluation forms to the database and creating reports from the data residing in the database. A high-level diagram of the PEP database is contained in Figure 1.

Senior Design Team Major Tasks

To accomplish the tasking outlined in the previous sections, the SDT had to again organize themselves to accomplish the design, development and testing activities associated with the systems life cycle. The distinct tasks they accomplished were:

- 1) Meet with the stakeholders (SEOR Faculty) to discuss the five items to ensure a complete understanding of the client requirements.
- 2) Refine the PEP system requirements specification.
- 3) Develop several prototypes of Items A-E and gain client feedback.
- 4) Develop testing criteria for Items A-E and perform test and quality assurance tests on prototypes.
- 5) Develop and deliver the final product.

Deliverable Items

The deliverable products expected from the SDT included:

- 1) PEP Systems Requirements Specification.
- 2) Process Model including short-term and long-term schedule of Ongoing Process and User Manual of process model.

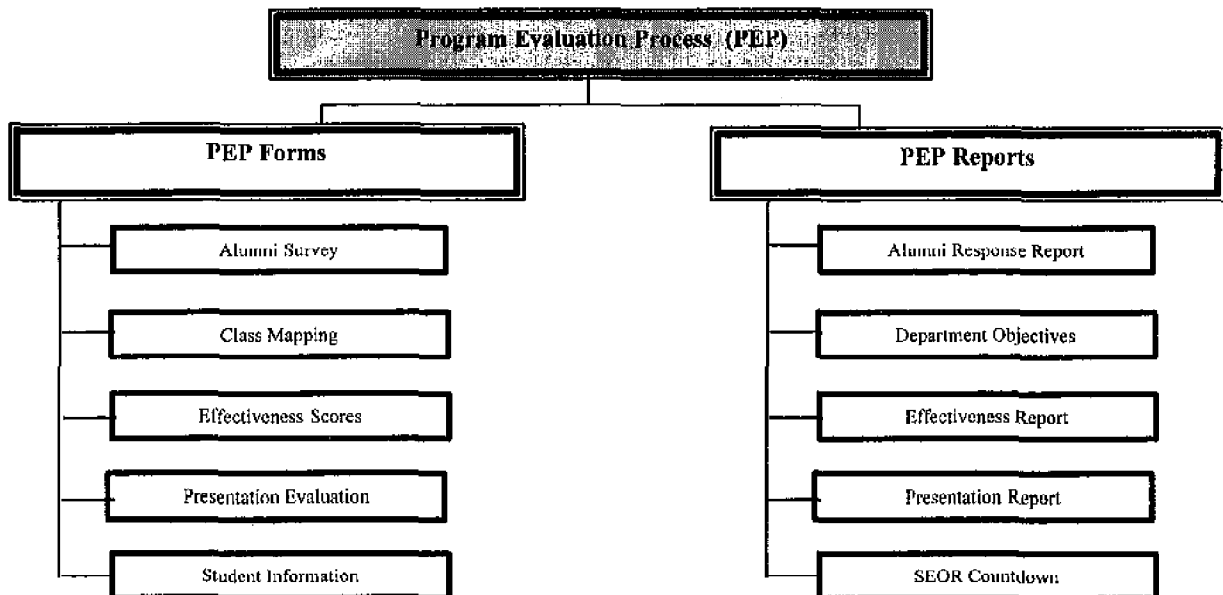


Figure 1 - PEP Database

- 3) Project Presentation Evaluation Form and User Manual.
- 4) Student Effectiveness Forms and User Manual.
- 5) Alumni Survey and User Manual.
- 6) Computerized System Support of the deliverable items.
- 7) Testing and Installation of the PEP system.
- 8) Training of administration personnel in the use of PEP
- 9) Final briefing of the system.

Management Plan

The purpose of the management plan is to define the organizational structure, detailed tasks and schedules, and responsibilities of the SDT. The management plan, which was required for both the first and second semester, provided a basis of directing, measuring, and controlling the progress of the project. The SDT was comprised of students with varying technical and management skills. These skills needed to be taken in to account when assigning individual students to their teams. It was a requirement to change the teams in the middle of each semester in order for everyone to have exposure to the different roles required in a typical system engineering team. The students decided which person would serve on which team. One requirement of the professor, however, was that everyone was required to be a member of the management team at least once during the year. Table 1 contains a list of the members with brief description of their skills pertinent to the project:

Table 1: Student Skills

	Skills:
Student 1	MS Office, MS Access, data modeling, HTML, C++, Test Analyst, IDEF0
Student 2	MS Office, Web Pages, Access, HTML, IDEF0, Data Flow Modeling
Student 3	MS Office, MS Access, HTML, Data flow, Project 98, Web pages, Java script and SQL
Student 4	MS office, C++, HTML, data flow modeling, IDEF0
Student 5	MS office, IDEF0, Web pages, Survey expert, C++
Student 6	MS office, IDEF0, Data Flow, Project 98, HTML, requirements analyst, Access, multimedia apps
Student 7	MS office, C++, HTML, IDEF0, dB admin, SQL, Visual Basic
Student 8	MS office, C++, Java, MS Access, IDEF0
Student 9	MS office, Web pages, HTML, C++, IDEF0, data flow modeling
Student 10	MS office, SQL, dB Admin, data modeling

The students were challenged with putting teams together to work on the various tasks since there was not enough time to have everyone work on every task. Using the skills of the individual team members, assignments were made to each task.

A representative application of the student skills to a particular task is contained in Table 2.

Table 2 - Skills Matrix for Item A technical tasks

	MS/Project	WP	EXCEL	ACCESS	Idef0	Other
Student 2		*	*	*		C++, HTML
Student 3	*		*	*		C++, Java, HTML
Student 6		*	*		*	C++
Student 8		*	*			C++, Java, HTML
Student 9			*	*	*	C++, HTML

This is the skills matrix necessary for Item A - Design a process for the SEOR department to use to meet Criteria 2 and 3 of the ABET2000 requirements. Table 3 contains the skills matrix for the testing group for this same item.

Table 3 - Skills Matrix for Item A testing tasks

	Capabilities
Student 1	Ms Office, IDEF0, C++, HTML, data modeling
Student 4	Ms Office, IDEF0, C++, HTML data modeling
Student 7	Ms Office, IDEF0, C++, HTML data modeling

Schedule

All prototype forms and final deliverables were completed by April 1999. The final presentation and delivery of the system was held on May 6, 1999. Stakeholders from the SEOR department as well as invited guests from other departments and the ITE Undergraduate Dean attended the final presentation.

Conclusion

The results from the first semester of this activity were very promising. The SDT met all of the expectations of the faculty. At the conclusion of the first semester, they were tasked with giving a formal presentation of their requirements gathering and recommendations for meeting the ABET 2000 requirements. The students proposed the five tasks that have been covered in this paper and

subsequently completed the design, implementation, and testing of the deliverables associated with each task. The faculty was very pleased with the deliverables of the SDT. The faculty was asked to use the Presentation Evaluation form of the PEP system to evaluate the SDT presentation. All of the marks were from the excellent, focused, and impressed categories, which are the highest categories on the form. The faculty expressed their deep appreciation to the students not only for the work they had done on the faculty's behalf for ABET 2000 accreditation but also for their professional endeavor in accomplishing all of the tasks given to them. They acknowledged that the students had proven their knowledge of the systems life cycle they had been taught in their classes leading to the Senior Design class.

References

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