AC 2010-1975: EXPERIENCE IN IMPLEMENTATION OF NSF WEB-BASED TECHNOLOGY PROJECTS IN CURRICULUM, COURSE, AND LABORATORY DEVELOPMENT FOR FIRST TIME NEW ABET ACCREDITATION

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Experience in Implementation of NSF Web-based Technology Projects in Curriculum, Course, and Laboratory Development for First Time ABET Accreditation

Abstract

The new Applied Engineering Technology Program at Drexel University received a first-time program accreditation from the Technology Accreditation Commission (TAC) of the Accreditation Board for Engineering and Technology (ABET). The self-study team was able to create a thorough and effective plan to assess the processes used for the ABET accreditation. The mission of the program is to provide contemporary students with an academic foundation and practical education in engineering technology through an outstanding curriculum and applied research program, and the participation of our students in one of the nation's most successful co-operative educational programs. Capitalizing on the success of the implementation of Web-based technology in the AET curriculum through the support of NSF CCLI Phase 1 and 2 projects since 2004, the quality of curriculum, course offerings, and laboratory facilities are improved to meet the program mission. The curriculum has been designed to incorporate web-based technology in our coursework: virtual simulation, experiments, and programming. Another successful element of the self-study and site visit preparation process was to document results from the NSF project outcomes to help insure that Program Educational Objectives (PEOs) were being satisfied, as required by the accrediting body. A sample of the graphical tools used to identify, track, collect, analyze, and report various outcomes as they relate to recent graduates of our AET Program is provided.

Introduction

The Applied Engineering Technology (AET) program at Drexel University (DU) was initiated as a response to job- and education-related issues expressed by government, academic institutions and industries across the nation. The mission of the AET Program is to provide contemporary students with an academic foundation and practical education in engineering technology through an outstanding curriculum and applied research program, and the participation of our students in one of the nation's most successful co-operative educational programs. Since fall of 2002, Drexel has been offering its AET major in collaboration with the Burlington County College (BCC), Delaware County Community College (DCCC), and Pennsylvania Institute of Technology (PIT) under a dual model, in which the students can pursue both AAS and BS degrees concurrently at these schools and their facilities.

In fall 2004, the AET major became available to the students at Drexel who intend to pursue the BS degree on a full- and part-time basis. The AET program's content provides an integrated educational experience directed toward developing the ability to apply the fundamental knowledge gained in Drexel's Goodwin College to the solution of practical problems in the engineering technology fields. The program clearly distinguishes itself from traditional engineering programs by applying a hands-on approach to the delivery of the courses. Over the past three years several state-of-the-art laboratories were developed. Key factors in this process include creation of the educational laboratories that can significantly contribute to the development of technologically literate students and workforce that could be in great demand not only in the tri-state area but also nationwide. The establishment of the state-of-the-art laboratories allows Drexel and its community college partners to develop training options for engineers and technologists located in the region's key industries. Development of Web-based technology laboratories for capstone courses by NSF CCLI Phase I (2004) and Phase II (2006) projects is described in this paper. With global competitiveness as the motivation, academia must develop advanced technology aligned with industry to eliminate competency gaps in the capabilities of engineering technology graduates. Information-based technology has become the new realm of manufacturing and mechanical engineering technology graduates. These two NSF projects help the AET program to prepare students to: apply discipline-specific theory, conduct experiments, and use real-world experience to interpret, analyze, and solve current and emerging technical problems.

The Internet-based technology laboratories are integrated with courses in robotics, mechatronics, thermodynamics, automation, and quality control. During the past six years, the courses MET 204 Applied Quality Control, MET 205 Robotics and Mechatronics, MET 310 Advanced Robotics and Mechatronics, MHT 205 Thermodynamics, INDE 470 Engineering Quality Methods, and MET 408 Manufacturing Information Management were offered to pre-junior and junior AET students. This facility allows all AET students at Drexel, as well as students at remote locations, to be involved in the same educational and training process in robotics, mechatronics, and quality control. In addition students can take advantage of these laboratories on schedules that are more flexible for them while having trained specialists available to help. One of the main goals of the project is to develop a national/international real-time E-quality laboratory with the mechatronics facility and provide greater course delivery flexibility for the enhancement of the student online laboratory learning. The Web-based technology developed at Drexel has been adopted by many engineering and engineering technology programs through national and international collaboration [1-2].

This paper also recounts some processes developed in the AET program's ABET Self-Study. These processes relate to assessment and evaluation of Program Outcomes that are also related to new web-based technologies incorporated into our curriculum[3-8]. These web-based technologies allow students to conduct virtual simulations, experiments and programming. The implementation of these technologies provides a leading-edge approach that industry is starting to incorporated into their operations. A course example assessment and evaluation will be presented which is followed by descriptions of other courses and where they support Program Outcomes (POs) and Program Educational Objectives (PEOs).

Consistency of the Program Educational Objectives with the Mission of the Program

Our Applied Engineering Technology program attracts students that see the advantages to a more hands-on, technologically-based academic program with meaningful experiences in the real world. The Program, by following the Program Educational Objectives listed in Table 1, prepares our students to succeed in a complex modern world. Each objective is a component of what our constituencies have developed, assessed and evaluated.

Table 1 – List of Program Educational Objectives

	Description
PEO 1	Apply discipline-specific theory, experiments and real world experience to interpret, analyze and solve current and emerging technical problems.
PEO 2	Communicate clearly and persuasively with technical and non-technical people in oral, written and graphical forms.
PEO 3	Function individually and on teams to design quality systems, components or processes in a timely, responsible and creative manner.
PEO 4	Demonstrate behavior consistent with professional ethics and are cognizant of social concerns as they relate to the practice of engineering technology.
PEO 5	Strive for professional growth and engage in lifelong learning.

The Applied Engineering Technology students meet all Program Educational Objectives. Our Continuous Quality Improvement Program report was available to the ABET visiting team and this report provided the evidence that supports the level of achievement of each PO and PEO.

Relationship of Program Outcomes to Program Educational Objectives: The Table 2 below describes how Program Outcomes contribute to the achievement of the Program Educational Objectives. Students enrolled in the Robotics and Mechatronics Laboratory, E-Quality Laboratory and Measurement and Thermodynamic Laboratories are assessed and this information is compiled with other assessment to determine to what extent they achieve PEO1, PEO2 and PEO3. Details of these courses follow:

Table 2 -Demonstrates relation between Criterion 2 Objectives and Criterion 3 Outcomes

Objective 1. We produce graduates who apply discipline-specific theory, experiments and real world experience to interpret, analyze and solve current and emerging technical problems.	***Objective 2.*** We produce graduates who communicate clearly and persuasively with technical and non-technical people in oral, written and graphical forms.	***Objective 3.*** We produce graduates who function individually and on teams to design quality systems, components or processes in a timely, responsible and creative manner.	***Objective 4.*** We produce graduates who demonstrate behavior consistent with professional ethics and are cognizant of social concerns as they relate to the practice of engineering technology.	***Objective 5.*** We produce graduates who strive for professional growth and engage in lifelong learning.
Outcome a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines.	***Outcome g.*** an ability to communicate effectively.	***Outcome e.*** an ability to function effectively on teams.	***Outcome i.*** an ability to understand professional, ethical and social responsibilities.	***Outcome h.*** a recognition of the need for, and an ability to engage in lifelong learning.
Outcome b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology.		***Outcome k.*** a commitment to quality, timeliness, and continuous improvement.	***Outcome j.*** a respect for diversity and a knowledge of contemporary professional societal and global issues.	
Outcome c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes.				
Outcome d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives.				
Outcome f. an ability to identify, analyze and solve technical problems.				

Robotics and Mechatronics Laboratory

The course provides a requisite understanding of Internet based robotics/automation/machine vision for students to progress to an advanced level in the curriculum. The course also serves as a means for students to gain exposure to advanced industrial automation concepts before their senior design project. The course has an applied learning focus, offering flexibility to the students through an open laboratory philosophy. Since the concepts of Internet based robotics and mechatronics are best conveyed through application-based learning, the course is divided into two components: a classroom lecture component and an associative laboratory component. All the devices such as robots, Computer Numerical Control (CNC), Web-cameras, and Programmable Logic Controllers are connected to the Ethernet. This almost eliminates the wire maze that is needed to link every device but still enables students to operate/control the equipment remotely. The controller of the robot (RCX40) can be connected to the Internet directly or to a computer using RS 232C cable on COM 1 port. The software used for communication is VIP for Windows Version 1.6.0 developed by the Yamaha Co. Ltd. The experimental setup includes the following items: ROCKWELL RSLogix 5000, Yamaha SCARA robot, RCX40 robot controller with optional on-board Ethernet card, Yamaha I/O checker, DLink DCS-5300, and HP m1050e PCs. The system also consists of power supplies, DC motors, fans, buzzers, limit switches, relays, and lights. The HAAS OM-1A is the first generation of high-speed CNC micro-milling machine in the HAAS Automation Inc. The machine has a repeatability of 0.0001 in and a maximum spindle speed of 40,000 rpm.

The courses, MET 205 Robotics & Mechatronics and MET 214 Computer Numerical Control, have been developed and offered to AET students since 2004. The course provides the students with a comprehensive knowledge of Internet-based robotics and automation using industrial robots and other common machinery and components. Laboratory assignments were used to emphasize important technological issues and provided hands-on design experience with the Internet-based technologies. The specific Internet-based technologies chosen were: computers and networks, robotics, automated inspection and vision systems, PLCs, sensors, automated assembly systems, and automated material handling. Various laboratory assignments were used to reinforce lecture information and to give hands-on design experience on Internet-based robotics and mechatronics.

E-Quality Laboratory

The instructional laboratory facilities are designed to sustain heavy student usage on a daily basis. Students start by building a Web server, specifying hardware, constructing inspection stations and developing or using quality control circuits and software. The inspection lab consists of Yamaha machine vision system, conveyor, sensors, two micro-LVDTs and a CMM to take measurement as parts are conveyed. The Rockwell Automation PLC DeviceNet is a communication link to connect the Internet with industrial devices (such as limit switches, photoelectric sensors, valve manifolds, motor starters, push buttons, bar code readers, variable frequency panel displays, and operator interfaces) to a network. Kistler Control Monitor CoMo View is used for monitoring industrial production processes, in which there is specific interrelation with a measurement as a function of time in electronic control, monitoring and evaluation as well as application-specific software for the measuring technology through the Internet. LabVIEW is powerful and flexible instrumentation and analysis software with graphical programming language developed by National Instruments

Corporation. LabVIEW has an extensive library of virtual instruments and functions for common control systems such as PLCs to aid programming. In order to operate and control the experiments from the Internet, communications can be established between the control computers and the remote users through AppletVIEW. AppletVIEW is an application kit for creating Java applets that communicate with LabVIEW. Figure 2 depicts the proposed lab module integration framework for E-quality control and factory automation.

The use of modern sensors, data acquisition instrumentation for monitoring and control manufacturing processes is implemented into laboratory practices in undergraduate classes on Web-based gauging, measurement, inspection, diagnostic system, and quality control. The network hardware and software components are integrated with quality methodologies to achieve maximum effectiveness in teaching E-quality concepts in various courses, including MET 204 Applied Quality Control, MET 310 Advanced Robotics and Mechatronics, and INDE 470 Engineering Quality Methods. In INDE 470, laser machining of plastics (acrylics) for applications to microfluidic 'lab-on-a-chip' devices offers an instructive and practical case study to teach *Six Sigma Quality Assurance* concepts and methods to Applied Engineering Technology (AET) students. A 10-week upper-level undergraduate course was developed that included a classroom component presenting lectures on Six Sigma principles and methods, combined with hands-on laboratory sessions that included product manufacture (laser machining of acrylic), and quality assessment measurements to support experimental design and data analysis in a Six Sigma framework. Acrylic sheets can be readily patterned with microfluidic circuits using a commercial CO_2 laser machining system that is representative of typical engineering prototyping and commercial manufacturing. The quality of the laser machining, particularly with regard to reproducibility, can be investigated as a function of laser power and speed, and also as the optical properties of various grades of acrylic stock. Students made various measurements of laser-machined parts using a co-ordinate measuring machine (CMM) and Internet-based machine vision (i.e., a CCD camera with image processing software). Students then analyzed measurement data to compare measurement techniques (Gage R&R), establish part variations, correlate quality metrics with laser processing parameters, and optimize the laser machining process using Design of Experiments.

Measurement and Thermodynamics Laboratory

Online education for Thermodynamics has intensified with the growth and extension of Internet technologies. Web-based educational environments may be more effective than conventional educational environments in a number of ways, particularly by facilitating communication among students. Student-oriented education can be achieved according to the learning ability and level of each student, because education is now possible whenever and wherever; at any time and any place. Many Internet-based tools and educational programs limit student ability to understand engineering principles, since they are mostly just visual-aid tools and do not simulate real time controlling and examining of operations. In the area of automation, the LabVIEW programming language provides the mechanism to remotely access controllable equipments through the Web. The experimental setup for the Internet-controllable vortex tube consists of:

- Source of compressed air (5HP electric compressor and air dryer unit)
- Pressure transducers (Omega Dyne Inc; Model: PX209-200A5V)
- Temperature transducers (Omega Engineering Inc; Model: TX91A-K2)

- Vortex Tube
- National Instrument-DAQ card (16 inputs, 16 bits, 200KS/s, Multifunction I/O for USB)
- LabVIEW software and server (Host Computer, IP Address: 144.118.xx.xxx)
- Client (PC downloaded with LabView Runtime Engine)
- Network IP Camera (Toshiba, Model: IK-WB21A with 22 x optical zoom, pan, tilt features)
- Flow Transducer/Controller (Mass flow controller: FMA 5400/5500 Omega and control valve)

Process Example

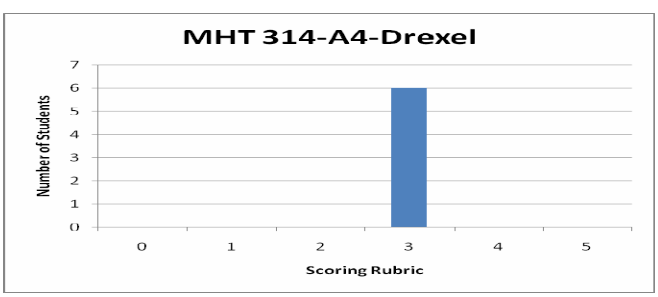
The Thermo and Heat Transfer Laboratory (MHT 314) explores basic thermodynamic relations and standard experiments that are related to heat transfer. Relevant to this paper, a vortex tube experiment allows students to verify the second law of thermodynamics. The experiment uses transducers and a data acquisition board that allows a LabVIEW program to fully control the experiment and manage the data accumulated. This experiment is web-based and can be conducted remotely through an internet connection.

In the academic year 08-09, Program Outcome a. – students employs modern tools used in their discipline - was assessed and the Course Assessment Summary Sheet is shown in Figure 1. Here the details of the course that are relevant to the assessment process are recorded. This information is compiled with other information in a Continuous Quality Improvement (CQI) Report that is generated annually. The CQI Report contains a summary shown in Figures 2 and 3 titled "Student Learning Outcomes at the Program Level" and the format is based on an ABET "Faculty Workshop on Assessing Program Outcomes"[3]. Here the results are summarized and any actions that may be required are recommended. A process for follow is included to make sure the recommendations are implemented. Similar processes are conducted for all courses. Included also are surveys of recent graduates, employers and student co-operative educational experiences.

Outcome Letter: **a**

Course Type: MHT	Course Number: 314
Section Number: 701	Campus Taught: Drexel
Term: Summer	Academic Year: 07-08

Performance Criterion Assessed: Employs modern tools used in their discipline.
Assessment Method: Locally developed examination
Educational Practices / Strategies: Coursework and Curricular Patterns



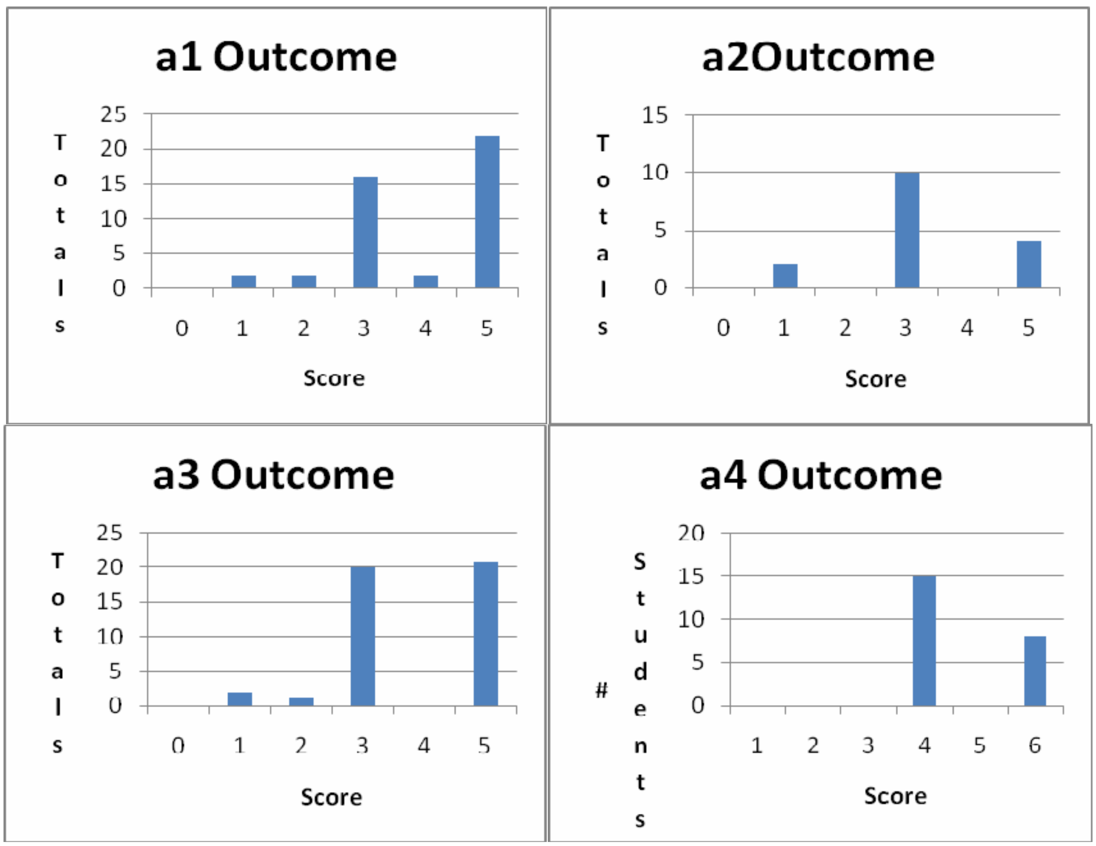
Average Score =3.00 1 Standard Deviation = 0.00

Figure 1 -Course Assessment Summary Sheet

Performance Criteria	Strategies	Assessment Method(s)	Context for Assessment	Time of data collection	Assessment Coordinator	Evaluation of Results
Demonstrates mastery of the skills of their discipline.	EET202, MHT222, MET421, MET422, MET423, EET404, MHT224, MHT405	Locally developed exams, external examiner, oral examinations, scoring rubrics	EET 202 MET 423	Start of academic year 07-08 on a three year cycle	William Danley	Department Assessment and Evaluation Committee
Applies techniques used in their discipline.	MHT205, MHT402, MET422, MET423, EET402	Locally developed exams, behavioral observations, scoring rubrics	MHT 205 MET 422	Start of academic year 07-08 on a three year cycle	William Danley	Department Assessment and Evaluation Committee
Demonstrates mastery of knowledge in their discipline.	EET206, MET421, MET422, MET423, EET407, MET380	Locally developed exams, external examiner, scoring rubrics	EET 206 MET 423	Start of academic year 07-08 on a three year cycle	William Danley	Department Assessment and Evaluation Committee
Employs modern tools used in their discipline.	MET100, MET310, EET324, MET422, MET423, MHT314	Locally developed exams, performance appraisal, scoring rubrics	MHT 314 MET 422	Start of academic year 07-08 on a three year cycle	William Danley	Department Assessment and Evaluation Committee

Figure 2 - Student Learning Outcomes at the Program Level

Results ___Summer 2008__ (date): It was observed that students achieved an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines. Here we see that 91%, 88%, 93% and 100% of scores from the Context for Assessment for courses and surveys met the Applied Engineering Technology goal. The included histograms show the results graphically. These results and some other capstone results from courses and surveys are presented. All performance criteria for this Program Outcome were assessed using triangulation from a variety of Assessment Methods and also encompassing the Educational Practices/Strategies as detailed in our Continuous Quality Improvement of the Program. The assessment summaries show agreement that the outcome was met through third party assessment.



Actions ___Summer 2008__ (date): Based on the analysis of these results, no action is recommended at this time.

Second-Cycle Results ________________(date): Since no actions were recommended, the evaluation process as outlined in Continuous Improvement – Process Timetable for Assessment and Evaluation of Applied Engineering Technology Program of our self-study will be reviewed as indicated in the schedule.

Figure 3. Description of Results and Actions with Histograms for Outcome *a*

To accomplish a comprehensive continuous quality improvement, on a macro level, AET program has developed PEOs that pertain to obtainable attributes that AET graduates should have as practioners in the field. To monitor that the PEOs are met the following assessment tools are implemented: Surveys, interviews, online electronic portfolios, performance-based assessment of project activities, and course evaluations. Figure 4 shows a value for each assessment over the past five years. The results show consistent high satisfaction with the program in a range between 4 and 5 at a full scale of 5. Since the demands in industry and technology are changing every year, this consistent feedback indicates that adequate changes are being made to improve program quality. Figure 4 also shows comparison in evaluation by all constituencies included in the assessment.

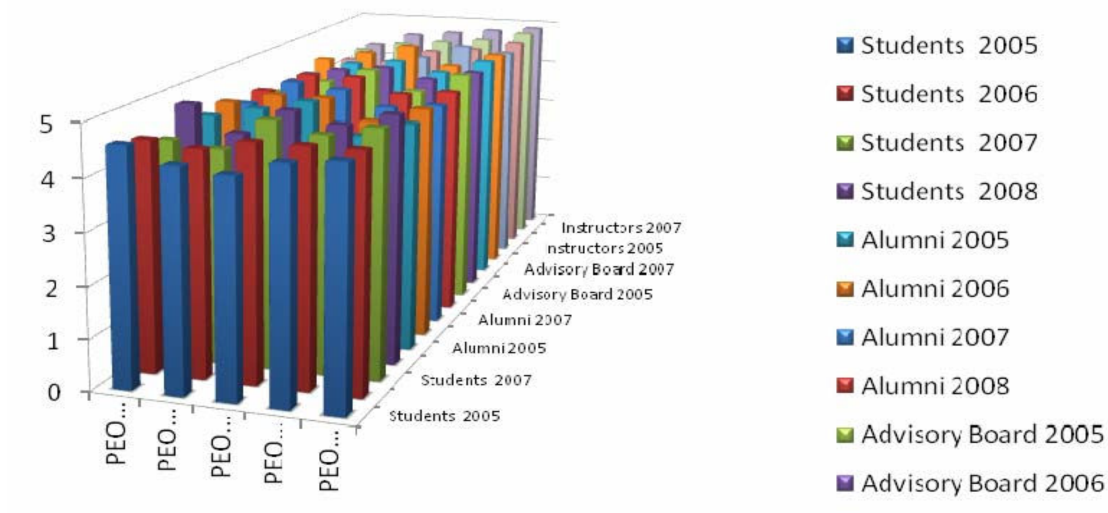


Figure 4: Evaluation results for Program Educational Objectives comparison chart

The NSF CCLI phase I and II projects have facilitated the integration of Internet-based technology education in E-quality for manufacturing at Drexel and delivery of appropriately designed courses in the engineering technology curriculum, which enables students of diverse educational backgrounds to enter the workforce. The findings from the project's external evaluator in 2009 confirm a successful completion of an integrated e-laboratory and courses with various tools. The experiments explored the use of Web-based maintenance, monitoring, inspection, diagnostics, and quality control in e-manufacturing.

Feedback from both internal and external assessors is essential throughout the program. Formal and informal assessment methodologies must be used in order to determine whether a program is meeting the needs of the discipline, or whether curriculum modifications need to be made to satisfy PEOs. The question of whether new educational experiences are needed based on evolving technological methodologies must be assessed by the faculty and by the students enrolled in a given program. Only through program assessment and continuous process improvement the needs of our students can be met.

During the ABET site visit, students and faculty explained how Web-based technology included in our curriculum contributed to the students achievement of PEO 1, 2, and 3. The ABET visiting team met with our AET students and Industrial Advisory Committee members. These students and Industrial Advisory Committee members provided valuable information to the visiting ABET team about the laboratory, curriculum, and course improvements. Additionally, it provided an opportunity for these students to interface with academic leaders from other institutions, and an opportunity to hone their communications skills as entry-level professionals in the discipline. The successful implementation of the projects phase I and II is crowned by the Applied Engineering Technology program's successful accreditation by the Technology Accreditation Commission of ABET. The AET program was granted accreditation and the ABET evaluation team found no deficiencies, concerns or weaknesses.

Conclusion

These Web-based technology projects and the courses that benefited from this research have fostered dramatic, positive technological change in the Applied Engineering Technology program of Drexel University's Goodwin College. Evidence of the success of these projects is strongly supported by the results of our continuous quality improvement report. Our students and other constituencies provided valuable information to the ABET Evaluation team about these important courses and resources. These personal interactions and our supporting documentation resulted in the successful AET program accreditation.

Acknowledgement

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