Is The Effort Worthwhile?

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Abstract - The senior mechanical engineering laboratory at UTC underwent major renovation-upgrading in 1996 with modern electronic instrumentation and LabVIEW being used in support of data acquisition, control, and presentation. During this eight year period of time, many observations and assessment activities were completed to show (1) that the new ME laboratory was a major element in insuring that our mechanical engineering students were meeting ABET 2000 outcomes, (2) that the university and private gift support used in developing the new laboratory was spent wisely, and (3) that the faculty involved in developing and teaching the new laboratory had developed new skills that supported continuing education, research, and regional industrial development. The paper will describe the observations and activities that have resulted from having the ME laboratory and its effect as we upgraded from our accreditation in engineering to the mechanical engineering program accreditation this past year.

Keywords: Instrumentation, Computer Data Acquisition, ABET outcomes

INTRODUCTION AND BACKGROUND

During the period of 1992 through 2000, the engineering faculty in the mechanical concentration at UT Chattanooga developed a mechanical engineering curriculum required to change the mechanical concentration in thermal and mechanics into a mechanical engineering program for accreditation by ABET. The engineering – mechanical specialty program at UTC had undergone progressive improvements following its initial accreditation in engineering in 1977 using feedback from its major constituents: faculty, graduates and employers. In 2000, the mechanical engineering curriculum was approved with two graduates completing the new ME program in summer 2003 prior to our ABET visit in fall 2003. In summer 2004, our program was granted ABET accreditation in mechanical engineering.

The lack of exposure to modern instrumentation and computer-based data acquisition tools was a concern in the engineering - mechanical specialty program offered prior to 2000 at UTC. On assessing the ME alumni in preparing the ABET self-study, we found that out graduates were not prepared to utilize computer-based data acquisition as they provided a score of 2.2 of 4.0, lowest of all scores from the assessment survey. This alumni response provided evidence that the new mechanical engineering program should have an increased emphasis on the study of modern instrumentation and utilization of computer-based data acquisition.

While developing the new curriculum, the ME faculty attempted to develop a "typical" undergraduate mechanical engineering program, one common to those from which each of the faculty had graduated. This common insight was thought to be the safe way to move towards developing a new ME program. But, this process of developing the new program could have seriously limited the full potential of the new program. The ME faculty were in general agreement in regard to including the traditional upper level mechanical engineering courses (thermodynamics, heat transfer, machine analysis & design, energy systems.) with modern computer software and modeling typical of academia and industry being used when appropriate. Some of the ME faculty noted the concern presented earlier and insisted that the new ME curriculum offer its students more than just the "typical" ME program learning experience by providing a comprehensive senior level laboratory experience typical of what modern industry generally aspires from a ME graduate. Many long-standing, accredited ME programs do not offer this experience to their undergraduate students. This insistence on providing an expanded senior level laboratory experience led the

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ME faculty ultimately to developing a comprehensive two credit-hour senior level ME laboratory having a three hour laboratory plus one hour lecture weekly.

THE STRUCTURE OF THE COURSE AND LABORATORY

The initial elements of this ME senior laboratory were first taught in 1996 when a one hour senior heat transfer laboratory was renovated and upgraded to include modern electronic instrumentation using LabVIEW in support of data acquisition, control, and presentation. When the opportunity came to develop the ME curriculum that was to seek mechanical engineering accreditation, the older two hour laboratory course was expanded into two 2-hour courses: ENME 347 (ME Experimentation) lecture-type course and ENME 447 (ME Experimentation Laboratory). In ENME 347, students learn about experimental measurements, basic computer data acquisition, error and uncertainty analysis, statistical data representation techniques, regression analysis, and modern sensoring devices and instrumentation techniques. Usually, ten laboratory experiments are conducted during the first ten weeks of the lab course with a comprehensive design project being completed during the remaining four weeks. The experimental design process, error and uncertainty analysis, LabVIEW programming, and the integration of modern data acquisition system activities are completed in the first half of the one hour lecture period associated with the laboratory course. Both lecture and laboratory periods are used to support the design project during the last four weeks of the course. [1, 2, 3]

HOW THE COURSE AND LABORATORY MET OUR ME PROGRAM OUTCOMES

In 2003, the ME faculty developed a self-study report to request consideration for upgrading our accreditation from engineering to a new mechanical engineering program as required for ABET. As all involved in preparing for an ABET review know, developing such a report is a daunting task. In our case, it was doubly daunting since we were attempting to upgrade to a mechanical engineering program accreditation while attempting to implement ABET 2000 Criteria for the first time.

The ME faculty recognized the merit of identifying the senior ME laboratory course in the new ME curriculum as a key course to achieve several of our program outcomes. ABET 2000 Criteria 3 included eleven outcomes requirements (commonly called the a-k). The senior ME laboratory course was found to be our major contributor to five of the criteria outcomes: b (an ability to design and conduct experiments, as well as to analyze and interpret data), c (an ability to design a system, component, or process to meet desired needs), e (an ability to identify, formulate, and solve engineering problems), g (an ability to communicate effectively), and k (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice). Also, Criteria 8 is addressed where a mechanical engineering program outcomes requiring that students have the ability to apply advanced mathematics through multivariable calculus and differential equations and the ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems.

Several other courses in the new ME curriculum contributed to the program meeting Criteria e and k outcomes. But, the ME Experimentation Laboratory was used exclusively to demonstrate that the new ME program graduates had met ABET Criteria 3 outcomes b and c. These outcomes were achieved through the ten laboratory experiments performed with a team report documenting their results and conclusions. Also, a team design project where a mechanical system was instrumented allowed team members to explore both thermal and mechanical system issues that needed to be evaluated. It is the project part of our laboratory course that creates a unique experience for the students. They are empowered to be responsible for developing, instrumenting, and reporting the results of their mechanical system.

During fall 2004, the ME Experimentation Laboratory consisted of seventeen students that were separated into four groups. For the design project part of the course, each group was asked to design a test plan for evaluating the change in exhaust emissions associated with moving from old to new technology combustion systems for the following devices: lawnmowers, chainsaws, leaf blowers, and weed eaters. Some of the devices used were donations from the Stihl Company so we could test and report to them some of our student's results. Each group developed a test plan, fabricated and integrated test systems with the internal combustion machines, completed the comprehensive testing addressing exhaust pollution, wrote a final report, and made oral presentations at the last class meeting. This effort provided evidence that both ABET 2000 Criteria 3 outcomes and ME Criteria 8 outcomes

have been demonstrated. A similar design project is completed each time the senior level ME laboratory course is taught. [4]

The new ME program would not have be able to demonstrate that it met ABET 2000 Criteria 3 outcomes b, c, e, and k as well as the ME program Criteria 8 outcomes without the inclusion of the senior level ME laboratory course. This lab course continuously evolves challenging both students and the course's instructors to develop and test systems that illustrate mechanical engineering principles using modern instrumentation and data acquisition techniques.

THE SUPPORT NEEDED TO MAINTAIN & OPERATE THE LABORATORY

The new ME laboratory course was developed using funding provided by the university, industry grants, and private foundations. Most of the laboratory systems used in this laboratory are renovated upgraded systems that have been used for many years. Approximately $150,000 has been used in the upgrade efforts while the same systems if purchased at current prices would represent an expense of over $700,000. Most of the renovation and upgrade costs were associated with adding modern instrumentation in parallel with older existing instrumentation and LabVIEW for data acquisition, control, and presentation.

The faculty members involved in developing the ME junior level experimentation course and senior level laboratory course received university faculty development grants enabling them to develop new skills associated with modern instrumentation and LabVIEW software being used for data acquisition, control, and presentation. These new skills allowed the faculty members to perform the laboratory renovations and upgrades while becoming more productive by conducting continuing education workshops, research, and industrial development projects. The College of Engineering and Computer Science at UTC received major side benefits from these activities as several design projects in the senior ME laboratory have been performed in renovating and upgrading other laboratory systems (Aerolab Supersonic Tunnel, Tinius Olsen Testing Machine, & the Fluid Flow Bench) used in various laboratories that all engineering students at UTC experience. Also, some design projects have involved performing upgrades on new mechanical engineering laboratory systems purchased from major vendors like TecQuipment. Our Dean of Engineering & Computer Science is pleased and very willing to provide funding to complete these activities, and the students in the senior ME Experimentation Laboratory have become excited knowing that their design project device will be used by future students in transitioning an older laboratory into the modern world of instrumentation. The students leaving the senior ME laboratory course have become accomplished system integrators and are very supportive of the other design projects that contain instrumentation and measurements. At UTC, all mechanical engineering students take a discipline based ME capstone design course ENME 450 that is a semester in length and our core interdisciplinary design project sequence, ENGR 385 & 485, that is a consecutive two-semesters in length taken by senior students in all five of our engineering disciplines**.** [5]

IS THE EFFORT WORTHWHILE?

Student responses to surveys used for assessment have shown that the mechanical engineering program's special emphasis on the junior level experimentation course and the senior level laboratory have received very positive feedback with many students claiming the activities in these experimentation courses have given them invaluable experience that has been applied in their places of employment.

In conclusion, all aspects associated with the evolving mechanical engineering laboratory effort have been very positive. Skills and learning experiences acquired by the students have been seriously advanced while the university has received fiscal benefits, and the faculty members involved have become more productive and capable of conducting research and other university activities that benefit the university and the public interest in general.

The final conclusion is YES! "The Effort is Worthwhile" in spite of the dedication and work required with maintaining complex computer-based laboratory systems.

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Charles V. Knight received B.S., M.S., and Ph.D. degrees in mechanical engineering from The University of Tennessee at Knoxville. Dr. Knight has been a member of The University of Tennessee at Chattanooga faculty since 1979, having taught at University of Tennessee campuses in Nashville and Knoxville ten years previously. His teaching interests are associated with fluid mechanics and thermal sciences. He completed six years of research for Tennessee Valley Authority associated with combustion and exhaust gas emissions and indoor air quality influences for wood burning heaters and boilers. He served as president of the Chattanooga Section of American Society of Mechanical Engineers in 1990 and chairman of Mechanical Engineering Division in 1986 and 1999 and general program chairman in 1988 for Southeaster Section of American Society for Engineering Education. More recently Dr. Knight has been responsible for mechanical engineering curriculum renovation, lab development, and directing the development of the ABET self-study report for the new mechanical engineering program at UTC. He is a registered Professional Engineer.

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Gary H. McDonald is currently a UC Foundation Associate Professor of Engineering in the Mechanical Engineering program at The University of Tennessee at Chattanooga. His teaching responsibilities include statics, dynamics, mechanics of materials, kinematics and dynamics of machinery, machine design, junior ME Experimentation lecture course, and senior ME Experimentation Laboratory. He received his B.S.M.E. in 1977, M.S.M.E. in 1979, and Ph.D. in Engineering in 1984 from Tennessee Technological University. Dr. McDonald was a NASA-ASEE Summer Fellow for four summers at the Marshall Space Flight Center in Huntsville, Alabama. He is a member of ASEE, NSPE, ASME (Chattanooga Section Chair in 1992), and is a registered Professional Engineer in Tennessee.