Continuous Improvement of a 2+2 Engineering Technology Program

A Ten Year Study

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Abstract

The University of New Hampshire Manchester (UNHM) offers a 2+2 program in Engineering Technology (ET) that has been accredited by the Accreditation Board of Engineering and Technology (ABET) since 1980. The UNHM-ET program is unique in that only the upper two years of program are offered and the entire student body has transferred from community colleges. Many unique challenges arise from this structure: meeting student expectations established during the first two years of study; curriculum alignment between multiple feeder schools; managing enrollments; and satisfying regional employers’ needs.

To address many of these challenges the UNHM-ET program has developed a set of effective tools to assist in a continuous improvement process. First, a UNHM-ET advisory board- consisting of Alumni, key Community College members, and Industrial partners- meets twice a year. Second, each year’s graduating class completes an anonymous survey about their UNHM-ET experience. Finally, employment-related outcomes (pre- and post-graduation) are tracked through the partnership between the UNHM-ET program and the UNHM Internship and Career Planning office (UNH-ICP). For the surveys extremely high attainment rates of 75 to 100 percent of the survey were achieved.

Introduction

The University of New Hampshire at Manchester Engineering Technology program (UNHM-ET) offers a 2+2 ABET accredited junior- and senior-level coursework for students who already have an appropriate associate degree. The majority of the student population comes from the New Hampshire Technical Institute (NHTI) after completing an Associate of Science in Engineering
Technology. Only two other programs in the country that are ABET accredited offer a 2+2 program with only junior- and senior level curriculum\(^1\).

UNH offers both Bachelor of Science degrees in Engineering and Engineering Technology each program is in different departments. The program was initially offered as a part of the continuing education program and was offered at night. Accreditation from ABET was granted in 1980 and students were given the option to take both day and night class. In 2001 the ET program physically moved from UNH’s main campus located in Durham N.H. to the Manchester N.H. campus. Manchester is the largest city in N.H. and located within commuting distance of NHTI and Nashua Community College (NCC). There is also a vibrant technology community that was lacking in the rural setting of Durham N.H.

![Total Engineering Technology Students](image)

**Figure 1**

Figure 1 shows the fall and spring enrollment numbers for the UNHM-ET program. The graph shows steady and consistent growth of the program since 1993. Figure 1 shows a spike in enrollment in 2001 which aligns with the relocation of the program.

Two disciplines of Engineering Technology are offered, Mechanical and Electrical. The ratio of Electrical to Mechanical Engineering Technology students is currently about two to three, consistent with the national trend\(^2\). The Electrical curriculum focuses on Digital Signal Processing,
Mixed Signal Microcontrollers, Integrated Digital systems and Integrated Analog systems. The Mechanical curriculum focuses on Fluids, Heat transfer, Mechanical Design, and Control Systems. Several courses cross over both disciplines such as Control Theory and Automation Engineering. Most students of these programs find jobs in a Manufacturing setting and stay in New Hampshire.

The Industrial Advisory Board

As part of the accreditation requirements the UNHM-ET program maintains an Industrial Advisory Board (ET-IAB). The ET-IAB is comprised of about twenty voluntary members. The group meets twice a year. No formal rules of parliamentary procedure are used and the meeting is mostly an open discussion forum, minutes are taken. The membership is comprised of industry members, recent graduates, local employers, members of the community college system and UNH administration. The meeting range from two to three hours in duration.

The ET-IAB agenda is drafted by program coordinator and faculty. A typical meeting starts with remarks from the dean of the college then the group discusses enrollment data, graduate job placement, accreditation status, partnerships status, research update, capstone project status, and curriculum.

The Continuous Improvement Plan (CIP)

ABET general criterion 4 states “The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program”

The UNHM-ET Continuous improvement plan, outlined in figure 2, is broken into three areas, Assessment, Analysis and Feedback.

The assessment portion of the plan consists of all sources of data that will be used to implement improvement. This data is collected from several areas spanning from assessment of student work to ET-IAB meeting minutes. Data can be taken by direct or indirect assessment. The stakeholders, assessment and evaluation are described below and in table 1.

UNH ET Stakeholders:

• Potential Students (Community Colleges)
• Current Students
• Past Students, Alumni
• Faculty
• New Hampshire, local, state governing bodies
• Employers
• Industrial Advisory Board

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The analysis portion of the CIP is where the data is gathered and summarized in graphical and tabulated forms. The data is then compared against the program objectives, student outcomes and the mission statements of the program and university.

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The feedback section of the plan is where the collected data and summaries are evaluated and action plans are developed. Evaluation can be done by the individual course instructor, the program coordinator, academic deans or advisory board. There is no standard format for an action plan as every assessment and evaluation process is unique. The loop is “closed” through the feedback of the stakeholders. Each time improvement, or change, it is necessary to find the appropriate stakeholders to evaluate the proposal.

The UNH Undergraduate Research Conference (UNH-URC)

For 18 years UNH has held the Undergraduate Research Conference (UNH-URC) University wide for all schools and disciplines. The purpose of this event is to showcase undergraduate research and has over 1,800 participants annually. The UNHM-ET program hosts an independent session to feature the results of a two semester eight credit capstone project.

Capstone projects can be assigned in several different ways. A student could be matched with a corporate sponsor and work at an off campus job site. Other projects may support faculty research. Some students have participated in inter-colligate technical competitions such as the Society of Automotive Engineers (SAE) Baja Buggy or Formula One events. In some cases students may have a research problem they have a personal interest in and must do a proposal and find the appropriate funding and materials. In all cases capstone projects require a sponsor who is responsible for thirty percent of the student’s grade. Each sponsor is given a questionnaire at the end of the project to evaluate student performance.

The Exit Interview Process

At the UNHM-ET URC members of the advisory board are given paper questionnaire to administer to the graduating students. The questions were based on the 2006 ETAC-ABET general criteria\(^3\). See Appendix 1 for the full questionnaire. The purpose of gathering this information was to identify potential areas of improvement for the UNH-ET program. Some studies\(^4\) question the value of asking student opinion as opposed to using direct assessment in the curriculum. The collection of this data was not meant to replace direct assessment, but only as another source of data.

It is not a formal requirement for students to complete the survey, as participation has no impact on their grading or assessment. The process is face to face, manual, and, on paper. Some discussions at the industrial advisory board have considered an on-line approach but it has been demonstrated that attainment rates drop when such a study is done digitally\(^5\). Participation is strongly encouraged and since the interview process started in the 2004/2005 academic year attainment rates ranging from 50 percent to 100 percent were achieved. Figure 3 shows the graduation rates and exit interview participants since the beginning of the study.
Exit Interview Data

The purpose of the compiling the exit interview data was to address issues and implement action plans to support the continuous improvement process. For this work the entire population of data will not be examined only a few representative trends. Three key questions (2.1, 2.4, and 3.1) were used to gauge the general perception of the student population in regards the quality of their experience at UNHM. The results of these questions are shown in Figure 4 and the specific questions from appendix 2 are listed below.

2.1 Faculty were approachable and willing to provide assistance
2.4 There was an effective balance of lecturing, discussion, and hands-on learning
3.1 What is your overall assessment of the program?
Question 2.1 speaks to the student’s perception of the approachability of faculty. Question 2.4 attempts to measure student perception on the balance of theory and practice. Since ET is a very hands on curriculum it is important to understand if students recognize the balance between theory and practice and to make sure the program has the right mix. Finally Question 3.1 asks students if they have a negative or positive perception of the program. It is clear that all three questions had a downward trend from 2008 to 2014.

The results of Question 3.2 is shown in figure 5 addresses the number of semesters it took students to complete the program. Since the UNHM-ET program is entirely a 2+2 most students have the expectation to complete a Bachelor of Science degree in only 4 semesters. 29% of the students take five to six semesters to complete the program.

After all the data and student comments were tabulated the information was shared at an annual UNHM-ET IAB meeting. The following areas listed below were highlighted as focus areas in need of improvement. Employment trends are included as it is an on-going focus area.
• Curriculum overlap with the community college
• Adjunct faculty performance
• Laboratory Facilities
• Semesters to Complete the program
• Employment Trends

Summary of Actions Taken in Focus Areas

Curriculum Overlap

The most obvious issues that needed addressing were related to curriculum overlap between the UNHM-ET program and its feeder schools. The improvement process began as a discussion during the IAB meeting where representatives from local employers and the community college system participated. For classes of concern syllabuses and catalog course description were reviewed and employers were asked their perspective on curriculum content. Table 2 lists the critical courses that needed to be addressed.
<table>
<thead>
<tr>
<th>NHTI</th>
<th>UNH</th>
</tr>
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<tbody>
<tr>
<td>Advanced Digital Electronics</td>
<td>Digital Systems</td>
</tr>
<tr>
<td>Calculus II</td>
<td>Analytical Methods (Differential Equations)</td>
</tr>
<tr>
<td>Electronics II</td>
<td>Analog Systems</td>
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<tr>
<td>Embedded Microsystems</td>
<td>Microcomputer Technology</td>
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<tr>
<td>Thermodynamics and Heat Transfer</td>
<td>Fluid Technology and Heat Transfer</td>
</tr>
<tr>
<td>Mechanical Design</td>
<td>MET Concepts in Analysis and Design</td>
</tr>
</tbody>
</table>

Table 2

The review highlighted that in some cases the exact same text was being used at both the Community college and the University. In one case the same adjunct was teaching at both schools and teaching identical curriculum. For the digital course students took the “Advanced” at the community college and felt the UNH curriculum was just a repeat. For the Microsystems class the students used the Motorola HC11 at the community college and the HC12 at UNH without much more distinction between the two classes.

The math requirement was particularly difficult to align. To enter the UNHM-ET program students only needed to take Calculus I. If a student expressed the desire to pursue a four year degree while at the community college they were encouraged to take Calculus II. The UNHM-ET program required students to take an ET specific Math course, Analytic Methods. This course attempted to cover applied mathematics topics specific to the ET curriculum. These topics include complex numbers, first order ordinary differential equations, and Laplace transforms. Students who had taken Calculus II were not required to take Analytic Methods. Since Differential Equations was not a program requirement this course sequence caused the population of students to have a different level of understanding of mathematics. Additionally Analytic Methods was not recognized as a prerequisite for graduate school. In order to simplify and have students with consistent backgrounds Analytic Methods was replaced with Calculus II and students are strongly encouraged to take Differential Equations.

Adjunct Faculty Performance

For residential tenure track faculty the teaching load is three courses per semester, adjuncts are used to cover courses that residential faculty cannot. Adjuncts are recruited from industry and are subject matter experts in their field. UNH students have the opportunity to evaluate faculty, both adjunct and residential, at the end of the semester. The questionnaire is approved by the faculty senate and consists of fourteen questions with responses ranging from one to five. The evaluations are administered on a paper evaluation form by a volunteer during the last week of the semester before finals week. Faculty members are not present in the room while the forms are being filled.
Students are also provided space to give written comments. The written comments are transcribed to keep the comments as anonymous as possible. The primary use of these student evaluations is for promotion and tenure documentation for tenure track faculty. Program coordinators, Division chairs and the Associate Dean of Academics Affairs are all given copies of the evaluations. Copies are made available in the library.

The ET exit interview data did not directly address the quality of the adjunct faculty but the student comments made it clear that there was room for improvement, see appendix 2. It was determined that some cases of the curriculum overlap was from adjunct syllabuses not be properly reviewed by the program coordinator. Other comments were the overuse of PowerPoint during lecture time. Students also commented that night courses were not running the full time.

From 2013 to 2016 all but one of the UNH-ET adjuncts were replaced. Some of the new adjuncts are residential faculty from the community college system and have done an excellent job in developing curriculum that does not overlap with their institutions. The student evaluations are now thoroughly reviewed each semester and comments from students during the exit interview are investigated. Additionally a request for a new residential ET faculty member has been submitted and is currently under review by the administration.

### Laboratory Facilities

**Mechanical Engineering Technology Laboratory Facilities**

A current initiative toward continuous improvement of the UNHM-ET is to equip the Manchester Campus with a laboratory for mechanical fabrication and testing. The goal is to provide students with opportunities for experiential learning that will complement their Bachelor’s degree studies. Previously, due such reasons as lack of availability of suitable space in previous buildings occupied by the college, lab facilities for the MET program have had fairly limited capability. This has been particularly true in regard to having a machine shop suitable for fabricating hardware needed for Capstone Projects, and the execution of Capstone-related testing.

The lack of such a lab is a particular shortcoming for a program like Mechanical Engineering Technology, where compared with traditional Mechanical engineering programs, there is a greater emphasis on the “hands-on” side of technical studies versus the theoretical. As pointed out previously, the students entering the UNH Engineering Technology Program all hold Associate’s Degrees in their disciplines. Nearly all of these students earned their Associate’s Degrees at a New Hampshire Community Colleges where their studies involved extensive amounts of work in well-equipped laboratories. The shortcomings in mechanical laboratory capabilities at Manchester have been widely noted in their exit interviews.
To redress this issue, an initiative is underway to transform of an approximately 1900 square-foot space on the ground floor of the present facility into a high-quality mechanical fabrication and testing laboratory. This will involve input from stakeholders in addition to the UNH Administration, including the ET-IAB, and local industry partners. It is likely that some co-funding will be sought from local industry for furnishing the laboratories.

In planning for this lab, the current size and scope of the UNHM-ET Program, and also an understanding that these needs may evolve over time have been taken into account. Overall, the range of machine shop capabilities to be incorporated initially is very similar to those found in the Mechanical Engineering Department facilities at the Durham campus. However, at first, the emphasis is on the ones that appear to be essential to have for a viable campus machine shop. Room is left for the shop facilities to grow according to needs that may arise in the future.

A second aspect under study is the appropriate amount of hands-on vs. theoretic study that is best for the 2-year Bachelor’s Program. It has been found that the students’ perceptions about shortcomings in laboratory facilities are rooted in their Associate’s Degree program experiences where they were being prepared for jobs with different skill-set requirements than those that they will pursue after earning a Bachelor’s Degree.

Electrical Engineering Technology Laboratory Facilities

The EET laboratory consisted of ten work stations which consisted of only analog oscilloscopes, multimeters, and function generators. That equipment is enough for an introduction to circuits ET curriculum but fall short for upper level EET study. A new Dell Optiplex PC was installed at each station. Each PC is equipped with Labview, Matlab, and Multisim. To support the automation curriculum Siemens PLC and HMI equipment was purchased with supporting software. The oscilloscopes were upgraded to the Tektronix MDO03014 with four analog channels, sixteen digital channels and a spectrum analyzer. Licenses for the Cadence Design system were purchased through the university program. Each station can access Cadence through a virtual server.

Capstone Project Laboratory Facilities

In the 2013 academic year through a grant from a private foundation a 1,800 square feet capstone project laboratory was opened for the ET program. Prior to this facility, all senior project work was done at industry sites using resources from the sponsoring company because labs on the UNH Manchester campus were at full capacity. This laboratory brings students back to campus by having a dedicated space for the Engineering Technology program and to leverage industry partners for equipment and resources to build a lasting infrastructure for showcasing students’ work. This facility has become a recruiting tool to attract potential ET students to UNH Manchester.
Semesters to Complete the Program

Since students enter the UNH-ET program as juniors it is reasonable to expect that they can complete the program after four semesters of study. Considering the challenging nature of an ET degree it is not unusual for students to take more than four years to finish the requirements for a Bachelor degree. Figure 5 shows the number of semesters to complete the UNH-ET program over the past ten years. 60% reported finishing in 4 semesters with 29% taking 5-6 semesters. This became an area of concern after a deeper look at the issue. The problem was with alignment of the UNH Discovery program that was not efficiently aligned with the community college general education requirements. This means students needed to be very careful what general education classes they took the first two years so they did not have to re-take similar classes that last two years. Additionally the ET program had very fixed course offerings with ET specific Math, Law and Business classes that only ran once a year. If a student missed one of these classes it set there completion date back an entire year.

UNH launched a Public Pathways program that mapped and aligned the Discovery program with the community colleges. Students and advisors have been given resources at the community college to help them choose the right courses during the first two years of the program. The ET program ended the practice of having ET specific courses for non-technical curriculum. This opened up the course catalog so students had more options to satisfy the Law, Business and Math requirements.

Employment Trends

Question 1.2 of the exit interview asks “Have you procured a permanent position”. The results are shown in figure 6. The data shows that over ten year only 38 percent of students had a secured a permanent position at the time the exit interview was conducted, a month before graduation. Additionally some of the comments in the exit interview, see appendix 2, stated more support for career services at UNH Manchester was needed.
In 2013 UNH Manchester started the Internship and Career Planning (ICP) center. The purpose of the ICP center is to help UNH Manchester students explore career options, create strategies for pursuing opportunities, and understand graduate school options. The center offers job search assistance; drop in resume evaluations, job data banks, mock interviews, along with many other career related resources.

One interesting project executed by the ICP center starting in the 2015/16 academic year was the first destination study. This study was an attempt to track student’s employment status pre- and post-graduation. The information was gathered by approaching students at a pre-graduation assembly, conducting classroom visits, and by calling students on the phone. Other methods of tracking students employment status was through social media on sites like LinkedIn and Facebook. Additionally the ICP center asked faculty if they knew the employment status of graduates that were not accounted for by other methods. Prior to the establishment of the ICP center the UNH-ET program attempted to track students post-graduation through mailing lists. That effort resulted in a less than a ten percent return rate. Most of the mail was returned do to inaccurate mailing addresses. The ICP approach was much more effective for the two years of the study. Overall knowledge rates for graduates were 96 percent for both the 2014/15 and 2015/16 cohort of students. For the 2014/15-74 percent, and 2015/16-78 percent of students were employed full time, part time, enrolled in a program of continuing education, participating in a volunteer
service or program, in the military, or travelling. The study breaks down employment status by Engineering Technology Discipline and how the employment status was determined.

The high knowledge rate of the ICP study in contrast to the low return rate of mail approach shows an effective method of tracking student employment status. It is also interesting to note the exit interview data regarding employment, 38 percent, was much lower than the ICP study. This result can be thought of in a couple of different ways. First the exit interview question was very specific in regards to position. The ICP study combined several outcomes for students post-graduation. Second, it shows that the majority of students find employment within the window of one month prior to graduation to thirty days after graduation.

Conclusion

This work described the continuous improvement plan for the UNHM Engineering Technology program. Over a period of ten years data was collected and evaluated to improve the quality of the program. Several areas of concern were highlighted, investigated and described. The data showed a downward trend of student satisfaction with the program from 2008 to 2013. By executing the CIP the trend was reversed and current student satisfaction is approaching its highest recorded levels. The relationship between the UNHM-ET program and its community college partners is critical for the success of both programs. The CIP described in this work had helped to align curriculum and improve the programs infrastructure. Finally the UNHM-ET program has partnered with the UNHM-ICP to help tract student success in gaining employment. The data collected showed high attainment rates for documenting student outcomes and very high job placement rates.

Appendix 1: Exit interview Questions
Number of students (sample)
1.1 Will you graduate this year
1.2 Have you procured a permanent position
2.1 Faculty were approachable and willing to provide assistance
2.2 My major coursework was intellectually stimulating
2.3 My courses prepared me for engaging in critical thinking
2.4 There was an effective balance of lecturing, discussion, and hands-on learning
2.5 You are familiar with the professional journals in your major
2.6 You understand the conventions of academic writing in your major field.
2.7 You are able to communicate effectively in a public settings
2.8 You are more aware of social issues
2.9 You were exposed to new ideas and new ways of thinking
2.10 To what extent is the Senior Project Capstone course a valuable part of the program
3.1 What is your overall assessment of the program
3.2 How long did it take to complete the upper two years

Appendix 2: Sample of Students Comments from the Exit Interview

Student Comments

Curriculum overlap

- Repeat courses from NHTI: analog and digital; analytical methods does not really meet the math needs of the program.
- I took several classes that were dumbed down versions of NHTI course (C programming & assembly language).
- Digital class repeat of NHTI was good refresher
- Digital systems repeat of NHTI, could’ve added something else to the class
- Microcontroller class, no new info from beyond NHTI
- Felt NHTI was more hands-on, missed that here at UNH
- Re-taking 3 classes already taken at NHTI, CTT MP & Tech Writing
- Some course material overlap and repetition
- Disconnect between NHTI and UNH ET programs
- The repetitive overlap of material that was previously taught at NHTI
  Repeating classes here at UNH
- Other courses used lab but again the material is repeated from NHTI.

Adjunct quality

- Adjuncts, lack of teaching experience
Adjuncts that taught curriculum that didn’t match the flow of what we had already learned
Most courses could be improved. The teaching quality in the business class is poor
Too many adjuncts
High number of adjuncts professors

Laboratory facilities

- More lab space and new updated equipment
- **Program needs more Hands on lab times (x6)**
  - Would’ve liked more hands-on
  - I prefer hands-on in learning
  - Should have had more lab work
  - More Hands On
- Lack of actual lab
- Needs more hands-on lab time plus less lecturing.
  - I only had one lab class with actual labs in the two years I was here.
  - Labs are severely lacking.
  - Not enough lab time
  - More labs
  - Poor lab facilities
  - Labs could be updated
  - Labs too few and not enough equipment or lab space
  - Need additional tools and instruments lab room too small in no organization
  - Mechanical lab is lacking
- More lab time would be valuable & better equipment

Did not have a lab (MET): NHTI courses were more enjoyable due to workshop/labs
In its current state program is poor due to lab conditions and changes in professional staff

Residential faculty quality, faculty churn

- I feel like I should have gotten a little more instruction from faculty

**Bibliography**


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