# AC 2009-569: DEVELOPMENT AND IMPLEMENTATION OF AN INTEGRATED OUTCOMES-BASED ASSESSMENT PLAN FOR A NEW ENGINEERING PROGRAM.

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# DEVELOPMENT AND IMPLEMENTATION OF AN INTEGRATED OUTCOMES-BASED ASSESSMENT PLAN FOR A NEW ENGINEERING PROGRAM


## Abstract

This paper describes development of an integrated assessment plan for a new mechanical engineering program as part of the preparation for the first ABET evaluation visit. To assess program learning outcomes and program educational objectives, the department has adopted numerous data collection and evaluation mechanisms. Courses at all levels of the curriculum have been selected to collect data. Course-based Fundamentals of Engineering Exam style tests, lab-based courses, senior capstone design project, field practicum, employer and graduate surveys and industrial advisory board feedback are utilized as assessment tools for both program learning outcomes and program educational objectives. Detailed description of the comprehensive assessment plan, its implementation, up-to-date results and plans for continuous improvement are presented.


## Introduction

The engineering program at Central Connecticut State University (CCSU) was started in fall 2006 augmenting existing Engineering Technology programs. The curriculum is designed to provide the student with the necessary tools for a career as a mechanical engineer, an engineering consultant, or for a career at post-graduate studies. The program is designed with two areas of specialization contained within the general degree offering through deliberate choice of electives. Students can opt for specializing in manufacturing or aerospace studies or simply complete the program in general mechanical engineering.

## Development of Program Educational Objectives, Outcomes, and Assessment Methods

The Program Educational Objectives (PEO's) are "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve "[1]. Thus, they apply to what the graduates should accomplish in the work place a few years after the graduation. Therefore, the assessment plan and data collection primarily rely on external constituencies.

The mission of the mechanical engineering program is to provide and sustain a quality, state-of-the-art education in mechanical engineering that enables students to develop specialized knowledge and experience required to practice as professional mechanical engineers or to pursue a course in graduate studies. To fulfill this mission, the department has adopted the following educational objectives that graduates from the program are expected to achieve [1] within a few years of obtaining a bachelor's degree in Mechanical Engineering from CCSU.

1. Graduates will be prepared in advanced mathematics through multivariate calculus and differential equations; they are prepared to utilize analytical techniques and problem solving skills necessary to adapt to technological and societal changes and for a career in mechanical engineering. Students will acquire the knowledge and application of fundamental engineering sciences common to most engineering disciplines (such as statics, dynamics, thermodynamics, and mechanics of materials); in the upper level mechanical engineering courses students will acquire in-depth principles of thermo-fluid sciences, mechanical systems and control, materials, mechanical design, finite element analysis and manufacturing.
   a. Through the aerospace specialization, students will both broaden and deepen their knowledge in aerospace materials, structures, propulsion, flight dynamics and control.
   b. Through the manufacturing specialization, students will broaden and deepen their knowledge manufacturing automation, systems design, strategy and simulation.
2. Graduates will acquire industry relevant experience within the academic environment through course projects, laboratory experimentation, classroom lecture and demonstrations.

3. Graduates will acquire in-depth knowledge in areas such as applied mechanics, computer-aided engineering graphics, design, and manufacturing processes.

4. Graduates will possess effective communication skills in oral, written, visual and graphic modes for interpersonal, team, and group environments.

5. Graduates will gain appreciation for the responsibility of the contemporary engineer by demonstrating professionalism and ethics including a commitment to utmost performance quality and timeliness, respect for diversity, awareness of international issues, and commitment to continuing professional development throughout their careers.

The Program Learning Outcomes (PLO's) describe "what the student's are expected to know or be able to do by the time of graduation. These relate to skills, knowledge, and behaviors that students acquire in their matriculation through the program" [1]. Students are the primary source of assessment data. The Accreditation Board of Engineering and Technology (ABET) Criterion 3 proposed guidelines for the competencies that graduates of engineering programs must attain upon graduation. A total of 14 PLO's have been adopted by the engineering department, which include EAC-ABET's criterion 3 a-k guidelines (in 1-11), in addition to three program specific outcomes as listed below for the reader's convenience.

1. Ability to apply the knowledge of mathematics, science and engineering principles to solve mechanical (manufacturing or aerospace) engineering problems. (a)
2. Ability to design and conduct experiments, and to analyze and interpret data. (b)
3. Ability to design a system, component or process to meet desired needs with respect to function and manufacturability, as well as to economic, ethical, environmental and sustainability, health and safety, social and political constraints. (c)
4. Ability to function effectively on multi-disciplinary teams and within a diverse environment.(d)
5. Ability to identify, formulate and solve engineering problems. (e)
6. Understanding of professionalism, ethics and associated responsibilities. (f)
7. Ability to communicate effectively in oral, written, visual and graphic modes.(g)
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
9. Recognition of the need for self-improvement through continuing education and the ability to engage in life-long learning. (i)
10. A knowledge of contemporary issues
11. Ability to use computational methods, skills, modern engineering tools and computers in engineering practice.(k)
12. ME1 The ability to apply advanced mathematics through multivariate calculus and differential equations.
13. ME2 The ability to use probability theory, statistics and linear algebra to formulate and solve engineering problems.
14. ME3 The ability to design, analyze, and optimize thermal and mechanical systems.

It is important to note that both Program Educational Objectives and Learning Outcomes are closely coupled, hence outcomes assessment also provide information on the program educational objectives.

## Assessment Strategy

The vision of the engineering department is an accredited program in mechanical engineering which serves the state and region by providing a quality engineering education that enables students to achieve excellence in their field of study and professional practice. To realize this vision, the initial assessment strategies were developed as part of the application for licensure which was submitted to Connecticut Department of Higher Education (DHE) and approved in April 2006. The Department of Engineering at CCSU will be seeking initial accreditation in 2009-2010 evaluation cycle. The specific methods of assessment can be divided into two major categories, namely, internal and external. The internal methods encompass exams within specific courses, performance appraisal rubrics used to evaluate the senior project course, lab reports, computer projects, and exit interviews prior to graduation. The external methods include Alumni and employer surveys, along with Industrial Advisory Board (IAB) focus groups [2].

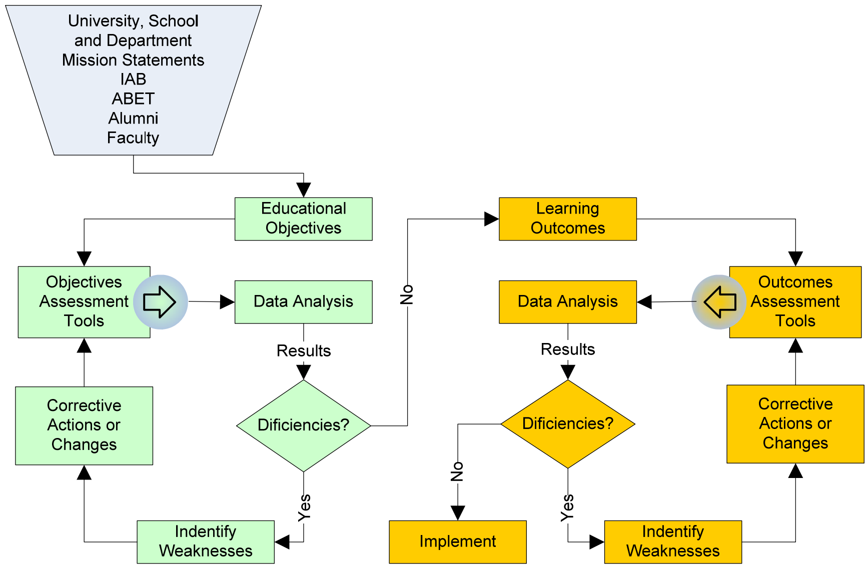


Figure 1. General assessment flowchart

The flow diagram outlining our general assessment and evaluation processes of the program is shown in Figure 1. The diagram illustrates the connection between assessment and evaluation of the Program Educational Objectives and Program Learning Outcomes. Development and implementation of effective assessment and evaluation mechanisms require well thought-out processes and reliable sources of interpretable data that can be used to identify weaknesses and strengths of our program. Such a task would require full engagement of all faculty members to identify how well the curriculum maps to the PEO's and PLO's in addition to data collection instruments.

| | ME Curriculum Coverage of Program Learning Outcomes and Program Educational Objectives | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Entries indicate level at which learning outcomes or Educational objectives are addressed in the ME courses | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | Not Addressed | | | 1 | Minimally Addressed | | | | 2 | Adequetly Addressed | | | | 3 | Thoroughly addressed | | | | 1 | Yes | | | 0 | NO | | |
| | Learning Outcomes* | | | | | | | | | | | | | | Educational Objective** | | | | | Indicate method used*** | | | | | | | |
| Courses | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | ME1 | ME2 | ME3 | PEO 1 | PEO 2 | PEO 3 | PEO 4 | PEO 5 | FE | CP | LR/DA | EP/EP | EXT | RUB | ETH | O |
| ENGR 251 | 3 | 0 | 2 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 46 | 20 | 31 | 22 | 50 | 23 | 35 | 14 | 20 | 14 | 41 | 19 | 24 | 31 | 31 | 37 | 27 | 34 | 15 | | | | | | | | |
| Index | 0.639 | 0.278 | 0.431 | 0.306 | 0.694 | 0.319 | 0.486 | 0.194 | 0.278 | 0.194 | 0.569 | 0.264 | 0.333 | 0.431 | 0.431 | 0.514 | 0.375 | 0.472 | 0.208 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | |
|---|---|---|
| FE | Fundamentals of Engring Exam style (FE)-course-based Exam | Suggestions |
| CP | Computer Project | |
| LR/DA | lab Report, Design Assignments, Examination | |
| EP/EP | E-portfolio E-project | |
| EXT | Exit Interview | |
| RUB | Rubrics | |
| ETH | Ethics Test | |
| O | Other | |

Figure 2. Excerpt from the curriculum evaluation index.

Figure 2 shows an excerpt of the curriculum coverage evaluation spreadsheet to both PEO's and PLO's. The entries are provided by one or more faculty member per course. Each PEO or PLO index is calculated by dividing the total score of the outcome by the maximum possible which is simply the number of courses multiplied by 3 which signifies that a certain outcome is fully addressed by the course. This tool provided valuable information not only about the strength of coverage, but also initiated the embedded feedback-loop in the evaluation and assessment processes at all levels. For example, if an outcome is not strongly addressed, instructors may be asked to address that issue in course contents, subjects covered, course activities, and evaluations methods to mention a few. In addition to the curriculum coverage strength index, the above evaluation sheet measures the contribution of each course to the PLO's and PEO's. This index is obtained by sum of the row of the outcomes or objectives and divided by the total maximum contribution of courses under consideration. In our case, 24 program technical courses are considered; therefore, maximum possible total outcome points is given by:

$$\frac{14 \text{ Outcomes}}{\text{Course}} \times (24 \text{ Courses}) \times 3 \text{ points} = 1008 \text{ outcome points}$$

The course contribution index for the course shown in Figure 2 is 15/1008 = 1.48%. The contribution level will also initiate the feedback loop mentioned above. It is important to note that the course contribution index is based on the assumption that all outcomes are equally weighted; this might be improved by assigning weights to each outcome as appropriate, and by using the non-technical courses (General Education) to assess soft skills [3-6]. Currently our evaluation is based on technical courses and will close the loop by adding non-technical courses if deemed necessary.

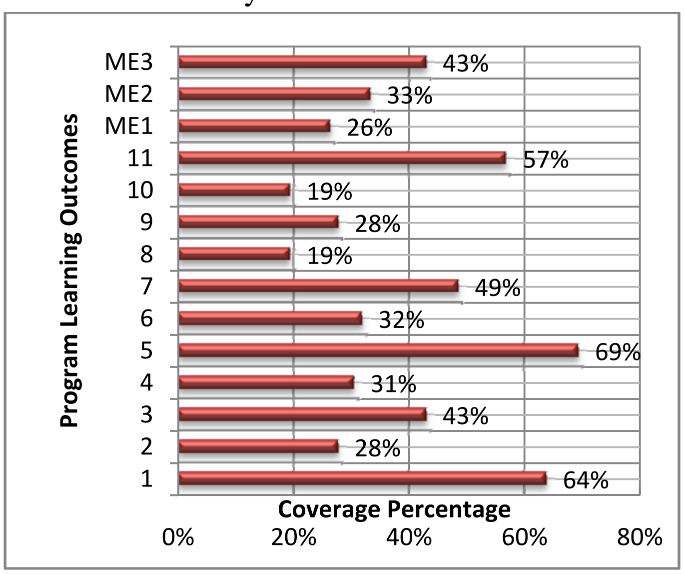


Figure 3. Program learning outcomes index.

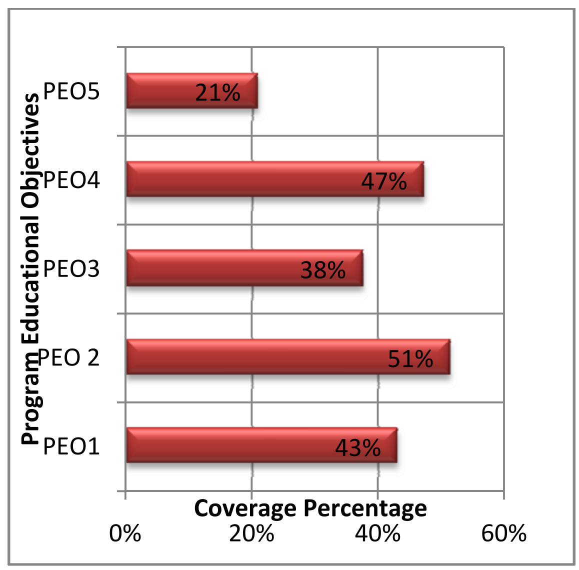


Figure 4. Program educational objectives index.

## Educational Objectives Assessment

The educational objectives were developed based on the mission statements of the University, School and the Department as shown in Figure 1. The first graduating class of the program is expected by the end of spring 2009, obviously, for a new program like ours, data will not be available to assess PEO's. As mentioned above, the PEO's are a measure of the competencies expected from the graduates in their early professional practice as engineers. Part of the graduation requirements from the program is a 400 hours practicum that can be met through cooperative work assignments in industry.

| Central Connecticut State University<br>Department of Engineering | | | | | |
|---|---|---|---|---|---|
| **Mechanical Engineerinh Program Field Practicum Evaluation Form** | | | | | |
| The Field Practicum Evaluation Form requires that you rate the student's performance on 14 program outcomes followed by 5 education objectives. This evaluation form is confidential and should be completed by the student's supervisor if and only if the student satisfactorily complete the 400 hours practicum. Please email the completed form to program coordinator | | | | | |
| **To be completed by the student** | | | | | |
| Student Name | | email | | | |
| Supervisor Name | | email | | | |
| Company | | Phone | | | |
| Address | | State | | Zip | |
| **To be completed by the Supervisor** | | Date | | | |
| The student statisfactorly completed the 400 hrs practicum : | | | | ☑ Yes | ☐ No |
| If your answer is NO, Please don't continue | | | | | |

| 0 | | | Question# | Excellent | Adequate | Marginal | Unsatisfactor | N/A | 1-14 Program Outcomes: What the program faculty intend students to be able to be able to know, do, or think upon completion of a degree program.<br>15-20: Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. |
|---|---|---|---|---|---|---|---|---|---|

Figure 5. Excerpt from the professional practicum evaluation form.

To jump-start the assessment process of the PEO's at such an early stage, the department has developed a field practicum evaluation form shown in Figure 5. The student's supervisors are asked directly by the department to evaluate students' performance (where applicable) in the practicum. In addition to the questionnaires, supervisors are encouraged to provide comments and/or suggestions that they may have. The response rate of such an approach will be very high compared to the regular employers' surveys. Consequently, this will help in providing valuable and timely feedback to proactively address any deficiencies.

The practicum evaluation is a short-term mechanism for a long-term goal, therefore it is planned to use several data collection long-term mechanisms to assess the performance of our students in the first 4 or 5 years of their engineering career. A biannual alumni survey will be used to collect data from graduates after two years, and four years of their employment. An employer survey will also be used in conjunction with Alumni surveys. Both surveys will have a provision for suggestions, comments, and concerns that students and employers might have. The Industrial Advisory Board, faculty focus groups will close the loop and make the necessary recommendations to correct any deficiencies.

## Learning Outcomes Assessment

Program Learning Outcomes assessment data collection started right at the inception of the program in fall 2006. Core courses at all levels have been identified to collect data using different methodologies to address one or more of the program learning outcomes. Course-based Fundamentals of Engineering Exam style tests, lab-based courses, senior capstone design project, field practicum, employer and graduate surveys and industrial advisory board feedback are utilized as assessment tools for both program learning outcomes and program educational objectives.

Table 1. ME Program Learning Outcomes Assessment Plan

| Outcome | | Course to Measure (see Program sheet for course subjects) | Data Collection Methodology | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ABET | Dept. | | FE Exam | Computer Project | lab Report Design Assignments, Examination | E-portfolio E-project | Exit Interview | Rubrics | Ethics Test |
| a | 1 | ENGR 251, ENGR 257 ENGR 252, ME 252, ME 354, | | | | | | | |
| b | 2 | ME 370, ME 497 | | | | | | | |
| c | 3 | ME 258, ME 498 | | | | | | | |
| d | 4 | ME 370, ME 498 | | | | | | | |
| e | 5 | ENGR 251, ENGR 257 | | | | | | | |
| f | 6 | ENGR 150, ME 498 | | | | | | | |
| g | 7 | ME 370, ME 498 | | | | | | | |
| h | 8 | ME 498 | | | | | | | |
| i | 9 | ME 498 | | | | | | | |
| j | 10 | ME 498 | | | | | | | |
| k | 11 | ME 403, ETM 260, ETM 467 | | | | | | | |
| Dept. | ME1 | ME 454, ME403 | | | | | | | |
| | ME2 | ME 345 | | | | | | | |
| | ME3 | ME 258, ME 367, ME454 | | | | | | | |

Data collection and analysis are underway using the tools listed in
Table 1 as they become available, results of curriculum evaluation index and course contribution percentages outlined in Figure 2 were used in identifying the data source courses. In the following sections a detailed assessment process of the program learning outcomes and educational objectives are outlined utilizing internal and external measures. All criteria are rated per the scale in Table 2.

Table 2. Outcome Assessment Rating Scale

| Rating | Comment |
|---|---|
| 1 | Not Fulfilled (not attained) |
| 2 | Attained (70% minimal) |
| 3 | Meets (80% fulfilled) |
| 4 | Exceeds (90% fulfilled) |

***Course-Based Fundamental of Engineering (FE) Exams***

The Fundamentals of Engineering (FE) Examination (administered by the National Council of Examiners for Engineers and Surveyors, NCEES) has been extensively used as a data source [7-11]. The exam is the only nationally-normed test in engineering that can be used as a quantitative metric for outcome assessment. The general exam covers most fundamental areas of science and engineering that can be directly mapped to ABET criteria 3. One of the critiques of the test is that it is a pass-fail test, with no minimum passing grade in any subset of questions pertaining to certain subject area, therefore, passing the test does not mean competency in any specific subjects area [10].

The model adopted for mechanical engineering in the department is different than the approach based on the overall nationally administered comprehensive exam. The model is course-based given as the final exam or part of it. At this stage, five courses have been selected to collect data to assess PLO's 1, 3, and 5. Each exam is composed of 25 FE-style exam questions selected to cover all aspects of a typical undergraduate course expectations. The five selected courses are: statics, dynamics, mechanics of materials, thermodynamics, and fluid mechanics. The choice of mechanics series was intentional as they represent a prerequisite chain in addition to being core engineering courses. The questions were selected to address the outcomes identified in Table 1.

For analysis purposes, and to close the feedback loop in case of weaknesses, each exam is divided into subjects covered in class, for example, fluid mechanics is divided into the following sub-subjects: fluid properties, hydrostatics forces, energy, impulse, and momentum equations, similarity and similitude, internal flow and turbo machines. Similarly, dynamics was divided into three major categories, particle dynamics, rigid body dynamics, physics and math based questions. The first two categories include linear and angular motion, impulse and momentum principles, work-energy principles and friction, the questions in this category include problems that require integration, differentiation, and graphical analysis of dynamics problems. The Math and Physics category includes questions that students are expected to solve using their freshman physics and calculus background.

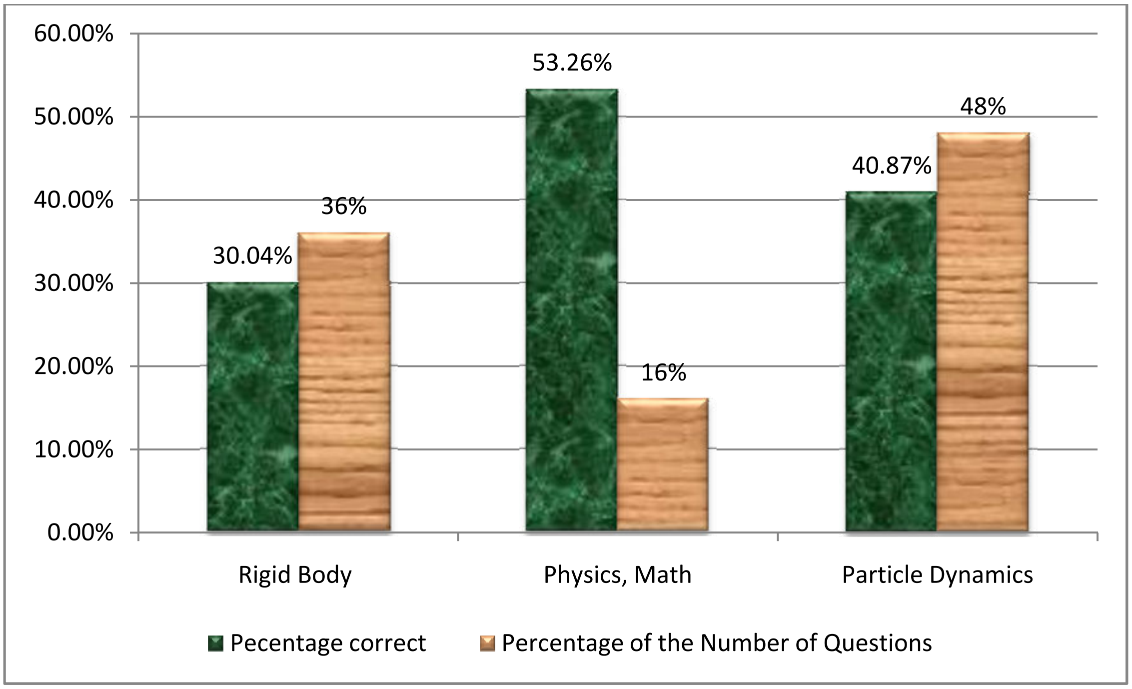


Figure 6. Breakdown of FE exam questions for ENGR -252 Engineering Mechanics II-Dynamics.

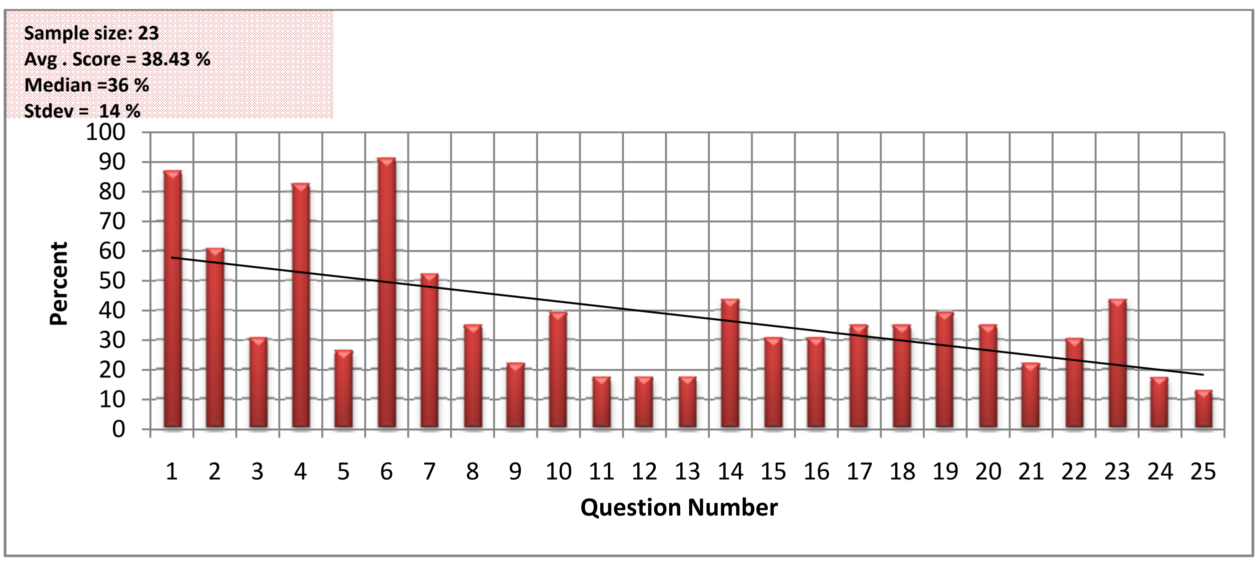


Figure 7. Engineering Mechanics II- Dynamics – Spring 08 – outcome evaluation tests results.

Although the sample size is too small for any statistical inference, it is obvious that at this point, the students performance is less than adequate. All exams were administered as part of the final exam, and sometimes as the final exam itself. Therefore it is expected that students have taken the matter seriously. However, when asked, many students expressed a high degree of dissatisfaction with using such an approach to assess their understanding of the subject matter.

Students attributed their frustration to several factors including difficulty of some of the exams, in particular Statics and Dynamics, not being well-trained for such a style of examination, and time constraints.

Further analysis of the Engineering Mechanics II- Dynamics course reveals general weaknesses in the basic sciences; again, it is important to note that sample size is too small for any conclusion or meaningful statistical inference at this stage. The time allowed for the dynamics exam was 75 minutes, which means 3 minutes per question. The nature of the questions is analytical, with virtually no chance to find the answer by inspection as seen in the actual NCEES administered exams. On the average, NCEES administered tests are rated 2 minutes per question, but with a reasonable number of questions that can be done by inspection. The time allowed for this test was not enough, and this can be easily seen in the trend line shown in Figure 7 , and this also was verified by students' feedback regarding the time allowed for this particular test.

Similar trend was noticed in the other four courses using this data collection mechanism. The results were discussed amongst faculty, and the recommendation is to continue using the same set of tests, and to see whether the trend will continue. Some of the potential remedies are to provide the students with sample tests and to increase the time or decrease the number of questions.

***Computer Exams/Projects***

Projects are evaluated on efficient use of the software, correct geometry, and whether project was completed on time. Computerized exams query students' ability to use software tools learned in a timely and effective manner in support of engineering concepts and practices. Examples of this assessment occur in the programs senior project research class, ME 497. This course, precursor to, or the first part of, the senior design project capstone, has as its aim the preparation of the general project proposal inclusive of applicable literature research and review to enable the project plan creation for future implementation. To support the possibility of experimental research, as well as to assist in the project phase, both Design of Experiments (DOE) and Project Management (PM) methodologies are reviewed invoking the in-house software packages Minitab® and MS Project®.

Introduced through review of developed backgrounds in statistics, probability theory, and regression analysis, the use of baseline factorial experimentation is expanded. Experiment design creation, randomization, and analysis of results are performed within the Minitab environment to obtain regression formulae including linear, interaction, full-quadratic, and beyond if desired. Partial factorials, including Plackett-Burman, are used as screening designs to limit the number of factors in cases where a multitude are considered to potentially influence results. Finally, response surface designs provide optimization together with the factor levels needed to achieve the desired results. A locally-generated computerized exam is used for assessment input to judge student understanding and effective use of the Minitab software tool.

Upon Industrial Advisory Board recommendation for PM inclusion in the program, the use of project management software is introduced in the research class. On an in-class computerized exam, students are presented with a project scenario where they create task and resource lists, assign resources to tasks, schedule work progression, track up-to-date progress, and report on project work completion and associated costs. Each of these and additional elements are graded and assessed following the exam. For final oral and written reports of the project proposal, student teams are required to apply the PM practices learned to their planned capstone project at hand through inclusion of MS Project output.

***E-Portfolio and Rubric***

An electronic portfolio is another method used in the assessment of our mechanical engineering program. Within ETM 260, the Computer-Aided-Design and Computer-Integrated-Manufacturing course, electronic files of student work are collected throughout the semester and the assignments are judged through a rubric assessing students ability to: Analyze and Interpret Data (which encompasses the accuracy of technical content, recording of data, use of units, analysis/evaluation of solutions, and math/science calculations); Design Various Assembly Projects; and Work in Teams and Organize the Project (conducting project planning, detailing and dimensioning).

***Capstone project***

The ME 498 class Senior Design Project uses a Rubric to evaluate the learning outcomes. The rubric evaluation scale is from 1 to 4, as shown in Table 2. The rubric is not a precise measure and it is difficult to be objective when evaluating student senior projects. However the rubric does identify large deficiencies in the learning outcomes. In the past, within the other established programs offered by the Department, the rubric has identified that students have difficulty with technical writing, spelling, syntax, and sentence structure. Also when the rubric was first introduced and used there was a weakness in the technical content and analytical capabilities of the students. As a result, the mechanical engineering program was created with more emphasis placed on mechanics courses (statics, dynamics, and strength of materials) and machine design. Also the finite element analysis course was changed to include hand calculations to verify all results.

The rubric has been in use for a number of years within engineering technology programs and no other relative deficiencies have been identified. At the end of this semester the mechanical engineering student projects will be thoroughly evaluated using the rubric. The rubric is filled out during the student presentation where the students are required to provide a summary report of their project. The course instructor can fill out the rubric or delegate it to other faculty or Industrial Advisory Board members that attend. The goal is to keep the evaluation process as objective as possible which is difficult in practice. The project should cover a design in depth, for example, mechanical engineering technology students conceptualized, designed, analyzed and manufactured a skiing-capable hybrid wheelchair shown in Figure 8. Current mechanical engineering students are primarily involved in design and fabrication of a moonbuggy for the NASA-sponsored race.

Figure 8. Senior project development of a hybrid wheelchair.

***Exit Interview and Focus Group***

The exit interview allows the senior students to evaluate the program from which they are graduating. On the questionnaire, they evaluate the learning outcomes on a scale from 1 to 4 similar to the capstone project rubric. It is interesting to note that in the past the students also identified that our programs were weak in the area of communications. Also during the interview phase these students specifically said that there was a problem with the technical writing portion of the program. The fact that the survey was supplemented with free-response was an advantage in pin-pointing technical writing as a concern. This highlights a problem with using only the learning outcomes as questions on a survey. Additional input is also elicited from graduating seniors through a focus group for program improvement involving the students, faculty, and IAB members. During these sessions, problems are not only identified, but potential solutions are proposed for program implementation.

## Conclusion and Lessons Learned

New programs may file for initial accreditation if they have at least one graduating student during the accreditation cycle in that year. To prepare for the self-study report and the accreditation visit, new programs must have their assessment ready for implementation upon the program inception. The first draft of the presented assessment plan was part of the application for licensure at the Connecticut Department of Higher Education.

The presented plan relies on multiple instruments to assess specific short-term and long-term goals. It is not expected that any one instrument is adequate to cover the full spectrum of technical and non-technical competencies that the graduates must develop during the program to ensure successful careers as practicing engineers. Therefore, diversification of the data collection resources and assessment instruments are one of the key elements of successful implementation of the plan. Another equally important aspect of the presented plan is the feedback mechanism. The concept of continuous improvement is incorporated in the plan at all levels starting at course assessments up to the adjustments that might be required to meet any changes in the institutional goals. For example, the PLO and PEO indices showed the sever lack of coverage on certain outcomes and objectives, which will force devising remediation to address these shortcomings.

There are many lessons that might be useful for development and implementation of assessment plans for programs seeking initial accreditation or re-accreditation. Assessment development and implementation is a huge task that cannot be handled by a couple of faculty and it is vital to get the whole faculty involved. Each, however, must have a clear responsibility for data collection. Review, analysis and documentation of the assessment results right after they become available. Aside from the logistics of dealing with data long after its collection, delays introduce discontinuities in the continuous improvement process.

Although the assessment plan outlined may appear overly rigorous to some, it should establish a clear baseline for the program. Additionally, the use of the FE style exam provides a quantitative measure for core competencies which can be gauged against national figures. If used for subject final examinations, aside from the development effort, these assessments require little additional faculty effort and provide immediate feedback to instructors for subsequent semesters regarding areas of weakness. For a program seeking its first accreditation, we believe that this extra initial effort spent (even redundancy in assessment measurement) will be advantageous towards our goal. We are pleased that our University administration values the assessment process and provided the necessary support to initiate the plan in both design and implementation.

**Acknowledgments**

The authors would like to thank the rest of our colleagues for their valuable and timely input in the preparation of the PLO's and PEO's indices.

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# Appendix

**Department of Engineering**
**Central Connecticut State University**
New Britain, Connecticut 06050
Tel: (860) 832-1815; Fax: (860) 832-1811
Web: technology.ccsu.edu

**Name:**______________________________________________
**ID#:**____________________ **E-mail:**________________________
**Entry:** Fall___Spring___Summer___Year____Transfer Credits____
**Advisor:**______________________________________________

**Degree: Bachelor of Science** **Major: Mechanical Engineering** **Effective: FALL 2009**
**Minor: Mathematics**

| General Education | Crs |
|---|---|
| **STUDY AREAS:** | |
| **I. Arts & Humanities (9 credits)** | |
| English Literature | 3 |
| PHIL or Fine Arts | 3 |
| English Literature or PHIL or Fine Arts | 3 |
| | |
| **II. Social Sciences (6 credits)** | |
| History | 3 |
| ECON or GEOG or HIST or POL. SCI. or ET 399 | 3 |
| | |
| **III. Behavioral Sciences (3 credits)** | |
| Anthropology or Psychology or Sociology | 3 |
| | |
| **IV. Natural Sciences (8 credits)** | |
| PHYS 125-Univ Physics I | 4 |
| PHYS 126-Univ Physics II | 4 |
| | |
| **SKILL AREAS:** | |
| **I. Communication Skills (6 credits)** | |
| ENG 110-Freshman Composition* | 3 |
| COMM 140-Public Speaking | 3 |
| | |
| **II. Mathematics *** | |
| MATH 152-Calculus I | 4 |
| MATH 221- Calculus II | 4 |
| | |
| **III.a Foreign Language (0-6 credits)**** | |
| | |
| | |
| **III.b International (6 credits)***** | |
| | |
| | |
| **IV. University Requirements (2-3 credits)****** | |
| PE 144-Fitness/Wellness | 2 or 3 |

* Placement examination may be required before enrolling in English and Mathematics.
**Refer to University Catalog, Academic Programs for

| Major Requirements | | | Sem. | |
|---|---|---|---|---|
| Course # | Course Name | Crs | F | S |
| ENGR 150 | Introduction to Engineering | 3 | X | X |
| ENGR 251 | Engineering Mechanics I- Statics | 3 | X | |
| ENGR 252 | Engineering Mechanics II - Dynamics | 3 | | X |
| ENGR 257 | Mechanics of Materials | 3 | | X |
| ME 216 | Manufacturing Engineering Processes | 3 | | X |
| ME 258 | Engineering Thermodynamics | 3 | | X |
| ME 345 | Engineering Statistical Analysis of Operations | 3 | X | |
| ME 354 | Fluid Mechanics | 3 | X | |
| ME 367 | Machine Design | 3 | | X |
| ME 370 | Instrumentation | 3 | | X |
| ME 454 | Heat Transfer | 3 | X | |
| ME 497 | Senior Project I: Project Research | 2 | X | |
| ME 498 | Senior Project II: Project Design | 2 | | X |
| **Electives or Specialization Requirements** | | | | |
| **General Engineering Electives** | | | | |
| | Technical Elective | 3 | | X |
| | ME Elective | 3 | X | |
| | ME Elective | 3 | | X |
| | ME Elective | 3 | | X |
| **Aerospace Specialization** | | | | |
| ME 403 | Mechanical Systems and Control | 3 | | X |
| ME 480 | Propulsion Systems | 3 | X | |
| ME 483 | Aerodynamics | 3 | | X |
| ME 486 | Aerospace Structures and Materials | 3 | | X |
| **Manufacturing Specialization** | | | | |
| MFG 226 | Principles of Numerical Control | 3 | | X |
| ME 360 | Manufacturing Operations Analysis and Simulation | 3 | X | |
| ME 460 | Manufacturing System Design | 3 | | X |
| ME 466 | Inventive Engineering Design | 3 | | X |
| **Additional Requirements** | | | | |
| CET 236 | Circuit Analysis | 3 | X | X |
| CHEM 161/62 | General Chemistry I | 4 | X | X |
| CHEM 163/64 | General Chemistry II | 4 | X | X |
| CS 151 | Computer Science I | 3 | X | X |
| ENG 403 | Technical Writing | 3 | X | X |
| ETM 260 | Computer Aided Design & Intergrated Manufacturing | 3 | X | X |
| ETM 356 | Materials Analysis | 3 | X | X |