Institutionalizing Continuous Improvement Plan in an Engineering Technology Department - Closing the Loop

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Institutionalizing Continuous Improvement Plan in an Engineering Technology Department – Closing the Loop

Abstract

Continuous improvement is a corner stone of a quality engineering or engineering technology program. Accreditation Board of Engineering and Technology requires that a well-planned and implemented continuous improvement plan should be in place.

> The ABET 2015-16 Criterion 4 Continuous Improvement[1] 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."

A successful continuous improvement plan that is institutionalized is self-driven and does not require external stimuli. For example, if an outcome assessment goal is not reached in an academic term, a sequence of events/actions are set in motion to address the deficiency. Evidence of existence of an institutionalized continuous improvement plan include but not limited to: A timeline of repeated activities related to the assessment and evaluation of student outcomes, agreed upon performance indicators to assess learning outcomes, systematic data collection focusing on *direct evidence* of student performance related to the student outcomes. Various data streams feeding into the assessment plan may include, course assessment data, senior exit survey, alumni and employer survey, internship reports and feedback from industrial advisory boards.

I. Introduction

The Accreditation Board for Engineering and Technology criteria, EC-2000 requires an assessment and continuous improvement plan. Since the first publication of outcome based criteria in 1995, considerable discussion has taken place on this issue.[1,2] In 2001 a similar outcome based criteria were published for the engineering technology programs. A number of studies were conducted and published under the Gateway Engineering Education Coalition outlining strategies for developing and institutionalizing such programs.[3-5] Many of these studies address important but only specific areas of the EC-2000 and TC2K criteria. For example, a study by Besterfield-Sacre et al. defines the eleven outcomes a-k in terms of blooms taxonomy.[4, 6] McGourtny, et. al., discuss incorporation of student peer review and feedback into the assessment process.[4] More recent studies have emphasized the continuous improvement aspect of the assessment process. According to Park continuous improvement process should have three characteristics: 1) the frequency of quality improvement work; 2) the depth and extent of its integration at different levels of the organization; and 3) the extent of contextualization within a system of work processes.[7] The process can be defined as “the planned, organized, and systematic process of ongoing, incremental and company-wide change of existing practices aimed at improving company performance”.[8] Through Byron’s research and belief in specific process for Continuous Improvement, the Shewart Cycle, also known as Plan-Do-Check-Act (PDCA) can be applied to all processes.[9] Based on the same concept provided by Byron’s paper, Christoforou begins with Assessment plan development with four strategies covering all the aspects, he begins addressing these outcomes in 3 categories of high (H), medium (M) and low (L) where high (H) signifies the utmost importance of knowledge or skill for student to perform successfully in the course whereas Low (L) signifies minor impact. Analyzing it further one of the action is taken- 1. The existing criterion is met: In this case, the criterion is reviewed and the results reported to the faculty and the college, 2. The existing criterion is not met: In this case an investigation is carried out to determine the causes.[9-10] The four strategies explained by Christoforou are similar to those explained by McGourty in his research are: 1) initiate a structured process to involve faculty and staff in the ongoing planning, development, and monitoring of the program; 2) offer "just-in-time" educational sessions to develop faculty and student knowledge and skills in assessment; 3) create an assessment toolbox providing administrators and faculty with templates that can be used in and outside the classroom; and 4) identify, review, and modify as required, key institutional practices to ensure that they are aligned with educational objectives and outcomes[3, 10]. The tools were used for analysis and it begun with Ishikawa and Pareto in 2001-2002 followed by check sheet, histogram, brainstorming, and failure mode and effects analysis (FMEA) in 2002-2003. The students discovered several errors in the documentation and hence provided suggestions for improvement.[11]

While others have attempted to present a serialized model based upon PDCA derived from six-sigma methodology, very few comprehensive models for assessment and continuous improvement have been published.[8, 11-12] It should be emphasized that a realistic model for assessment and continuous improvement must be dynamic and be able to evolve as learning and improvements take place. At the same time it should incorporate data from various assessment tools to continuously assess attainment of learning outcomes.

II. The Strategy

Three engineering technology programs at Old Dominion University underwent the TAC of ABET accreditation review process during fall of 2005 and again in fall of 2011. In preparation for the accreditation visit in 2005, a comprehensive assessment and continuous improvement plan was developed within the engineering technology department and adopted by all three programs.[13] This plan was subsequently used for the 2011 visit. In spite of the best intentions, the assessment process lacked institutionalization and participation by the entire faculty. The assessment process was viewed as an added burden by the faculty. The plan lacked faculty training and tools to implement standardized course assessment. In preparation for the 2017 visit, the plan was further revised with an aim to institutionalize. The revised plan incorporates following three strategies: 1. Create assessment tool box, 2. Provide Training for Faculty and 3.

Create a structured process for continuous improvement with built in monitoring and evaluation. These are further explained in sections III, IV and V.

III. Assessment Tool Box

Developing and implementing a comprehensive assessment and improvement plan presents several challenges. Administrators must provide resources to initiate and sustain such a program. Faculty must take the ownership of the design and implementation of the plan. Success of a continuous improvement plan also requires changes in the perception of the faculty about such activities and their proactive participation.

McGourty and Christoforou suggest to create an assessment toolbox providing administrators and faculty with templates that can be used in and outside the classroom. Two tools were developed to help faculty.[5, 10]

1. Course Assessment Spreadsheet (CAS) and
2. Faculty Course Assessment Report (FCAR)

FCARs have been used at a number of institutions with positive results. FACR is a two page report filled by the faculty member at the end of the semester to prepare a reflective assessment of the course. An example of FACR is included in the appendix. FCAR documents faculty member's thoughts about the course and what changes are required in future. It also captures grade distribution, modifications made to the course and course objective assessment. FACR provides the important element of a CIP by documenting future changes needed.

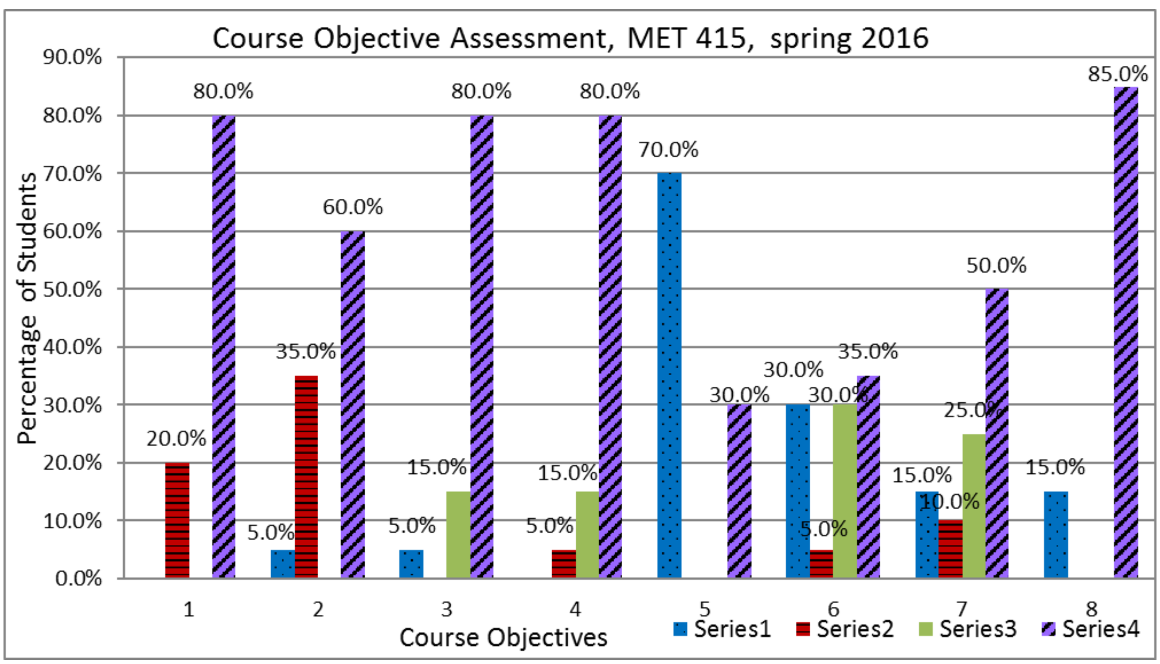


Figure-1. Course Objective Assessment

CAS or course assessment spreadsheet was developed to standardize the individual course assessment by various faculty. The process started with the identification of performance metrics for each outcome by the curriculum committee in each program. Each faculty member completes the CAS at the end of the semester and submits it to the program director. CAS evaluates course objective assessment and learning outcome assessment. Faculty determine the threshold for success and results are discussed in the program faculty meetings to identify critical issues and possible solutions. CAS generates the charts on course objective and learning outcomes which are shown in Fig. 1 and Fig. 2. Respectively.

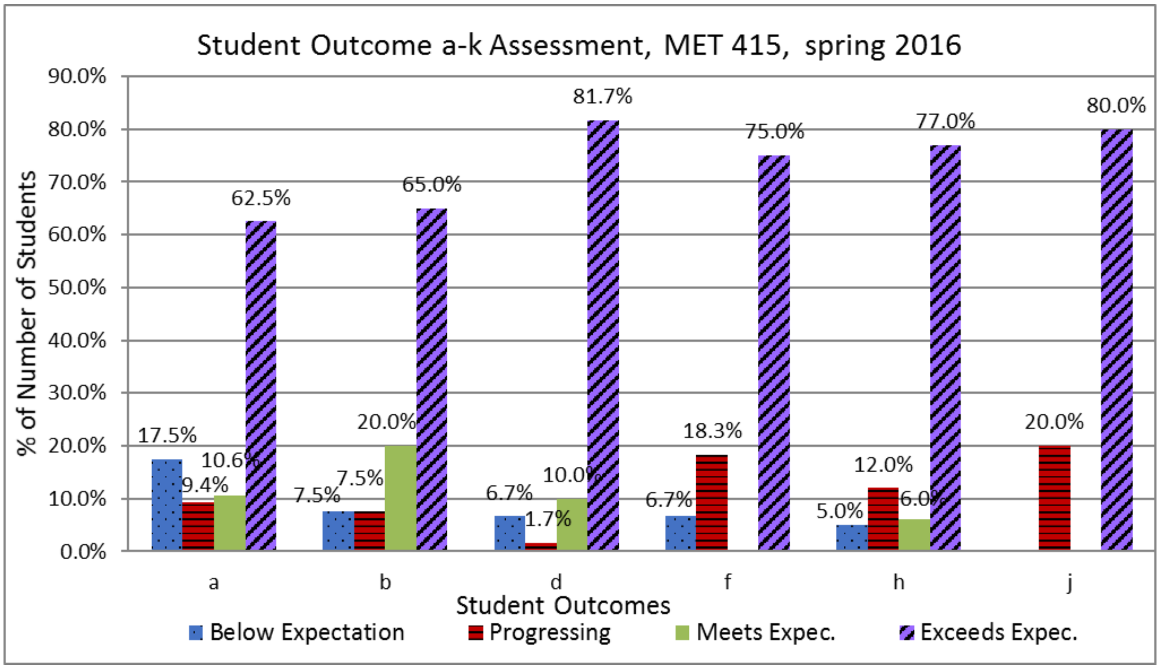


Figure-2. Course Outcome Assessment

IV. Faculty Training in Assessment

Training is crucial for the implementation and success of a continuous improvement plan. Faculty will become more efficient and productive if they are trained in the use of new assessment tools. Training also ensures that everyone is speaking the same language and person to person variation in the execution are minimized. The department organized assessment workshops for all faculty as part of the implementation plan. Faculty were trained not only in the use of new assessment tools but also in the process of assessment and the continuous improvement plan. At the end of the workshop faculty were invited to a hands-on session in completing their CAS and FACR.

V. Structured Process for Continuous Improvement

A well-structured process of continuous improvement is designed to be self-driven. It includes automatic triggers for action and has checks and balances in place to lead the action plan through completion. Faculty involvement at every step is the key for the success of the program and hence training for faculty becomes a critical element of this process. A continuous improvement model was presented by the author at the CIEC conference in 2007.[13] This model has been revised to include new assessment tools and presented in Section a. Section b presents the implementation of the model and efforts to institutionalize the process.

a. The Assessment and Continuous Improvement Model

The plan for assessment and continuous improvement presented here takes into account the dynamic nature of this process and includes two iterative loops for continuous improvement. The inner loop is a short term annual cycle which looks at the achievement of learning outcome using the course assessment spreadsheet and faculty course assessment reports. The assessment process starts with the mission statement and vision of the Institution, College and Department. These are translated into the objectives and goals for the Institution, College, Department and Programs. Cumulative results for all courses within a program are presented in a program assessment report to the chair. Subsequently, the department chair takes this data to prepare a departmental assessment report of student performance. The results of the individual course assessment are combined with the results of other assessment tools including senior capstone project assessment, senior exit survey, senior student satisfaction survey, cooperative education reports and feedback from the advisory committee. The model is shown in Figure 3.

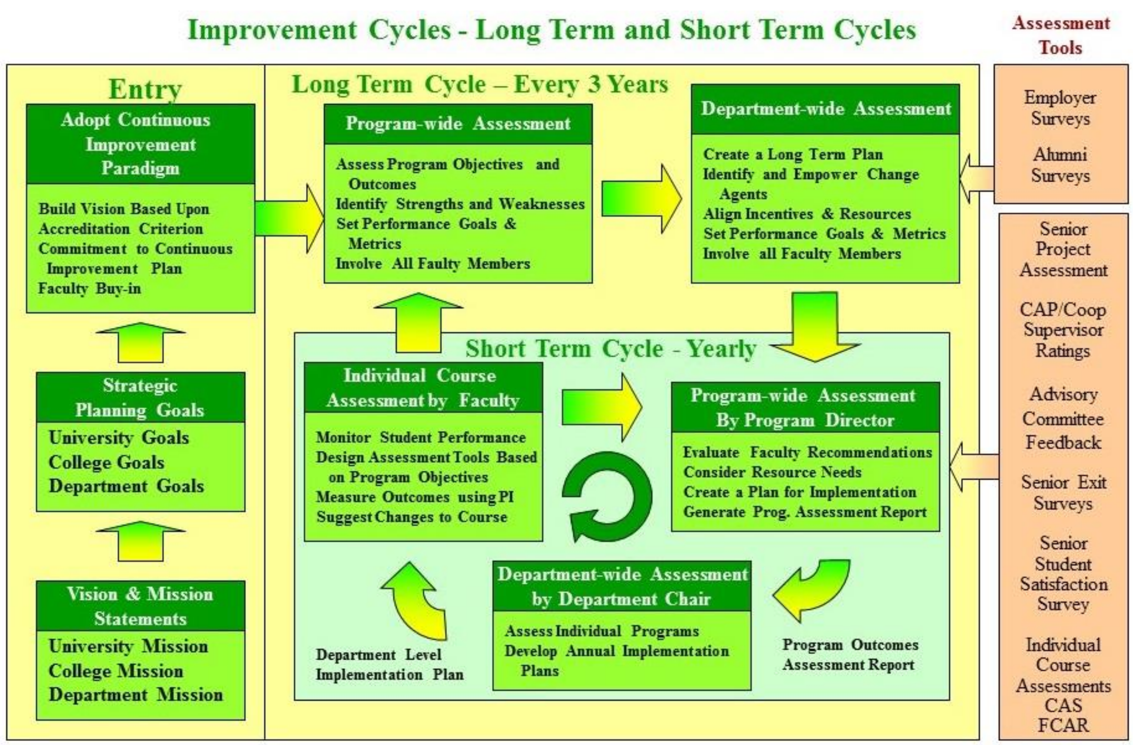


Figure-3. Continuous Improvement Model

The outer loop is the long term program assessment in which major reviews are done every three years. Primary assessment tools utilized here are alumni survey and employer surveys which are conducted every three years. In addition to these two tools, the major program review also utilizes the cumulative results from the short term tools used in the annual cycle. In order to be successful, the continuous improvement paradigm must be adopted at the highest level in the university and supported with resources for execution and implementation.

b. Implementation - Turning Vision into Reality

"Without execution strategy is useless." – Morris Chang

The implementation of short term cycle presented in the model above is crucial in institutionalizing the process. This is accomplished via a set of scheduled activities to perform assessment at various levels including curriculum committee, program and department level. The scheduled list of activities in the annual cycle and corresponding feedback loops are shown in Figure 4. It also shows the timeline for various meetings and assessment tools used to collect data. Multiple reviews including feed-back from Industrial Advisory Boards ensure that the process remains on track.

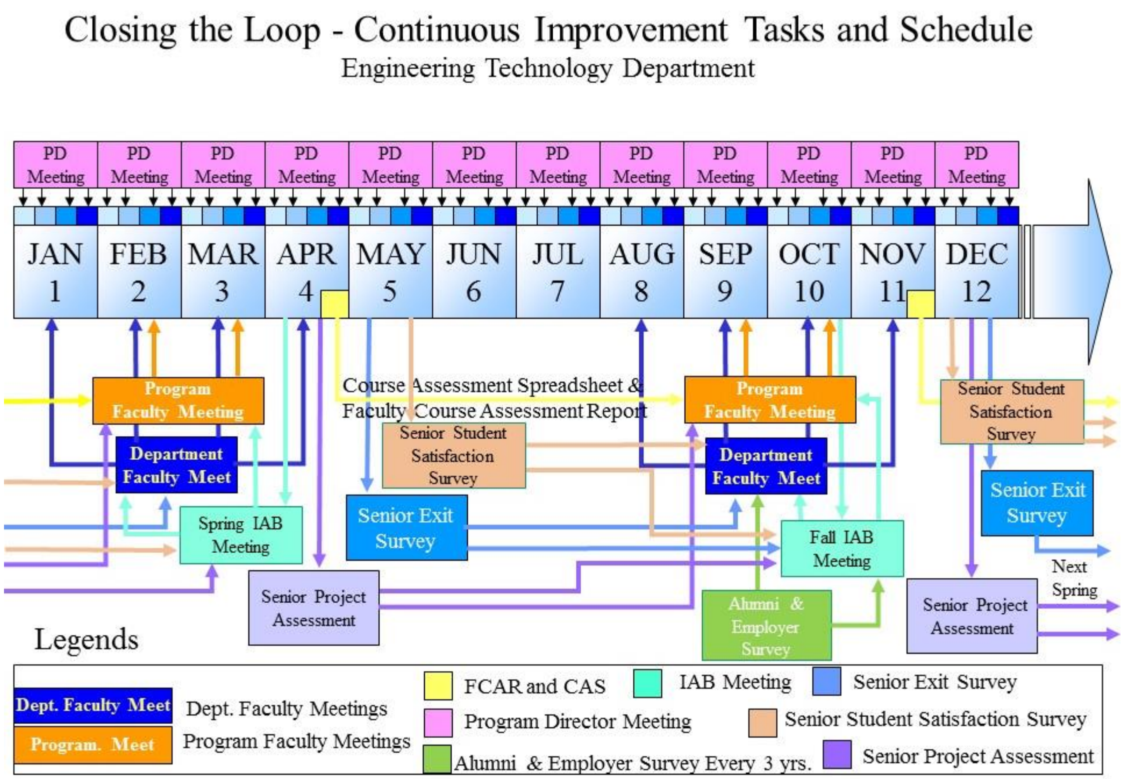


Figure-4. Continuous Improvement Tasks and Schedule

c. Time Commitment from Faculty

The implementation of the continuous improvement plan takes into account faculty workload. Only additional time commitment required of faculty is in the preparation of the course assessment spreadsheet and the faculty course assessment report at the end of the semester. Initially faculty were asked to prepare CAS and FCAR for all courses taught to get everyone used to the process. In future, faculty will prepare CAS and FCAR only for courses used in the specific outcome assessment scheduled during a particular year. Each program follows a schedule of outcome assessment over a three year cycle. This keeps the additional workload on faculty to a minimum. In addition, all faculty are provided training in the preparation of CAS and FACR. After initial learning curve, preparation of CAS and FCAR should not take more than 2-3 hours each.

d. Responsible Stakeholders

Various continuous improvement tasks outlined in Figure-4 are assigned to individuals and groups as shown in Table -1 below.

Table-1. Continuous Improvement Tasks and Responsible Stakeholders

No.	Assessment Tasks	Responsible Stakeholders	Frequency
1	Program Faculty Meetings	Faculty and Program Director	Monthly
2	Department Faculty Meetings	Faculty, Program Directors and Chair	Monthly
3	IAB Meetings	Faculty, Program Director, Chair and IAB members	Fall & Spring
4	Senior Project Assessment	Faculty, IAB Members	Fall & Spring
5	Senior Exit Survey	Program Director and Chair	Fall & Spring
6	Senior Student Satisfaction Survey (SSSS)	University	Fall & Spring
7	Alumni and Employer Survey	Chair and Program Directors	Every Three Years
8	Program Director Meetings	Program Directors and Chair	Bi-Weekly
9	FCAR and CAS	Faculty	Every Semester

e. Review and Monitoring

Periodic review and monitoring is an integral part of this continuous improvement model. Program educational objectives are reviewed every three years by the program faculty and the industry advisory board. Alumni and employer surveys are conducted every three years and the surveys are designed to assess both learning outcomes and program objectives. Other assessment tools like senior exit survey, project assessment, student satisfaction survey, as well as, individual course assessments of selected courses are conducted every semester.

All three programs have adopted the a-k learning outcomes listed in the TAC of ABET criteria. The faculty periodically review the results of the assessment process to assess achievement of outcomes and program objectives. These results are also discussed in program meetings, department faculty meetings and shared with the IAB members. Each program director prepares an assessment report of their program and submit it to the chair. The entire continuous improvement process is accomplished by various tasks scheduled throughout the year as shown in Figure 4.

VI. Use of Assessment Data and Role of Faculty

The curriculum committee of each program meets at least once a month to discuss the issues related to curriculum, laboratory facilities, assessment information and accreditation. The meeting is coordinated by the Program Director. Additional meetings both formal and informal may be held as needed. In addition, the department faculty meetings are held each month. In addition to the formal meeting described above, faculty provide input to the Program Director concerning equipment, facilities, equipment, and other concerns via e-mails and informal conversations.

Program directors compile the assessment data and create a program assessment report each year which is also entered into the university assessment system (WEAVE) for SAC's accreditation.

The role of the program faculty in the assessment and continuous improvement plan is as follows:

a. Faculty members are responsible for establishing course objectives and assessing whether they are being met. Faculty members complete the course assessment spreadsheet (CAS) which measures student performance for each of the course objectives and learning outcomes. A sample of this form is shown in Table 5.
b. Faculty prepare the faculty course assessment report (FCAR) at the end of each semester.
b. Faculty discuss their course assessment results shown in Figure 1 and 2 during the program faculty meeting.
c. The program director includes the results of these course assessments in the program assessment report.
d. Results from program assessment reports are presented to faculty during the department faculty meeting.
e. Faculty are responsible for implementing any curricular changes as a result of program review during the assessment process.
f. Faculty determine the acceptable levels for various performance metrics.
g. Faculty provide input in the design of various survey instruments.

Assessment data helps and guides faculty in making curricular changes. Any low score on a particular course objective or learning outcome raises a red flag and the issue is discussed in the curriculum meeting to find the root cause and a subsequent solution. If the issue affects other courses within the program, the issue is raised in the program faculty meeting. If the issue affects other programs within the department then, the issue is raised at the departmental faculty meeting. Finally, if the issue affects other departments, then the issue is raised within the undergraduate committee for the college.

VII. Conclusions

A comprehensive model for assessment and continuous improvement has been presented which takes into account the dynamic nature of the process while providing short term and long term review of learning outcomes and program objectives. The model also takes into account the iterative nature of the process by incorporating feedback loops for both short term and long term review process. The annual cycle provides a schedule of activities necessary to accomplish the review process. Results from multiple assessment tools are aggregated to provide attainment of learning outcomes for multiple years to identify trends in variation. The plan has been implemented successfully in all three engineering technology programs. Development of common assessment tools have helped in standardizing the assessment process.

Appendix

Faculty Course Assessment Report (FCAR)

Course No.__MET-455_____ Course Title _____Lean Engineering____ credits __3_

Semester ___Spring ___ Year____2015_____ Instructor _______Alok K. Verma______

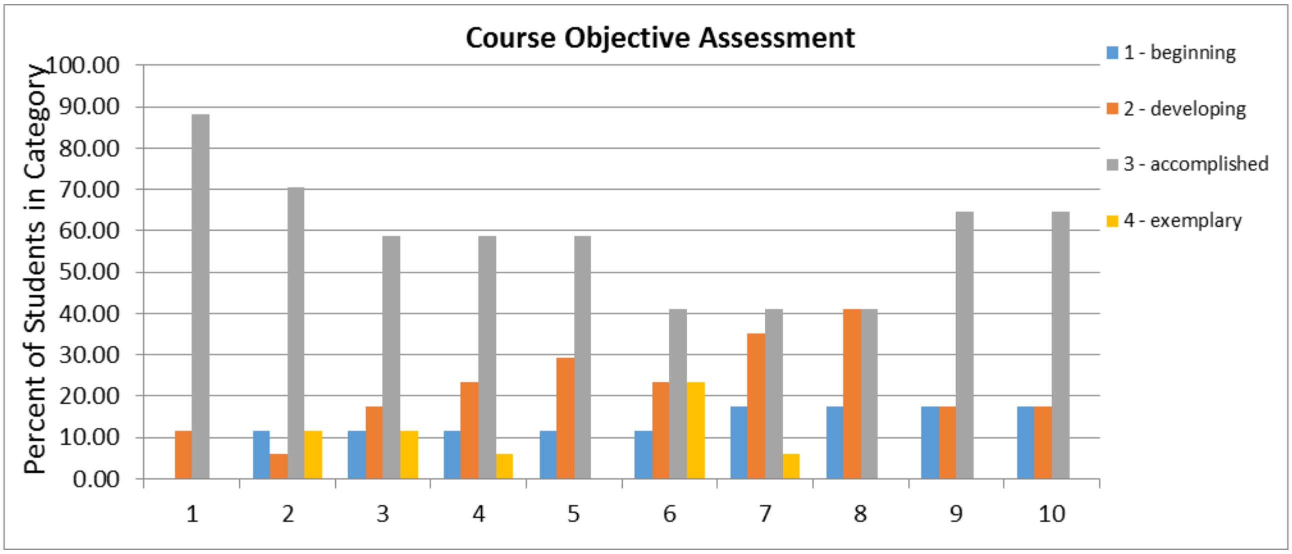
Catalog Description:
Lecture 3 hours; 3 Credits. Prerequisite: Senior Standing and MET 200. This course looks at the history of lean and six sigma philosophies, their principles and implementation methodologies for creating a world class enterprise. Topics in Lean include five s, value stream mapping, cellular manufacturing, pull system, performance metrics, Lean supplier network, Lean product development, lean implementation models and impact of these technologies on the society. All MET technical electives require a research paper which has significant writing and research component and this research paper will constitute 25% of grade. Class activities may involve physical simulation of production environment.

Grade Distribution:

A	B	C	D	F	W	Total
1	5	7	1	3		17

Modifications Made to Course:
Lean Engineering course was developed at the suggestion of the industrial advisory board of the MET program. The original contents of the course emphasized Lean and Six Sigma topics. In view of the application of Lean principles to product development and supply chain areas, two more modules were added to the course. A comprehensive research report was also added as a requirement of the course to improve writing skills of students in support of the university's initiative "Writing Across the Discipline." In addition a number of class room activities have been added to engage students. Classroom activities include vale stream mapping, Dice rolling activity and histogram plot, SIPOC activity, control chart activity and Measurement System Evaluation activity.

Course Objective Assessment:
The target for this course is that 60% of students should be in top two categories of exemplary and accomplished. The chart below shows the percentage of students in each of the four categories. The categories are defined as follows:
Beginning -Bottom 40%; Developing – Next 20%; Accomplished – Next 20% and Exemplary – Top 20%
The chart shows that for course objective no. 5 – *Ability to apply lean tools in manufacturing and business environment.* Percentage of students in the top two categories is 59%
The chart shows that for course objective no. 7 – *Create a pull based manufacturing system using Kanbans* percentage of students in the top two categories is 47% and that for objective no 8 - *Understand the importance of building quality in the processes and controlling quality* that number Is 41%.
All other course objectives are met.



Student Feedback:
Student comments during the semester indicated that students enjoyed the classroom activities however they had difficulty with six sigma topics like measurement system evaluation.

Reflection:
Students had difficulty understanding the concepts of quality control and measurement system evaluation systems in six sigma. This could be partly due to lack of knowledge and experience in statistics. More time is needed for these topics.

Proposed Actions for Improvement:
Student performance in the course were below expectation on course objectives 5, 7 and 8 which relate to Application of Lean principles to business and manufacturing environment, creating a pull based system and understanding quality principles. Instruction on these topics will be reinforced with added classroom activities and homework assignments.

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