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Hybrid Evaluation/Assessment Development (HEAD): Utilizing Mastery of Subject in Concert with Traditional Methods for Outcome Improvement

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Abstract

The College of Science and Technology at Fairmont State University provides TAC of ABET accredited 2+2 engineering technology programs leading to associate and baccalaureate degrees in several disciplines. Similarly, the Department of Engineering Technology at the University of North Carolina at Charlotte has recently implemented lower division programs to complement longstanding TAC of ABET accredited +2 upper division programs in multiple disciplines. The authors desire to answer the question: How can course outcomes be consistently measured and evaluated in order for meaningful course improvements to take place? This paper provides a snapshot of a possible answer where a combination of mastery of subject evaluation and traditional evaluation of course outcomes, the Hybrid Evaluation/Assessment Development (HEAD) is initially tested.

The authors present a pilot class (at Fairmont State University) to frame future evaluations of the effectiveness of the HEAD Method. A transitional version, extending the pilot class and this study, will be offered at UNC Charlotte next semester. The division between the mastery of subject and traditional methods took place with deriving the Measurable Course Outcomes (MCO). An MCO is a "topic" heading that comprises skill sets found in engineering mechanics and are referenced to ABET criterion and Blooms taxonomy. An example of a low level Bloom's taxonomy example is seen in quiz #3 as follows:

> *Quiz #3 - Measurable Learner Outcome: Understand basic engineering mechanics principals (Blooms taxonomy - Knowledge, comprehension; ABET Criterion 1.a)*
>
> *Skill sets required for Quiz #3:*
>
> 11) *Define statics, strength of materials, and dynamics*
> 12) *Define force*
> 13) *Distinguish scalar and vector quantities*
> 14) *Recite Newton's Laws*
> 15) *Define types of forces*
> 16) *Define types of force systems*
> 17) *Define principle of transmissibility*

Higher level, analytical applications are also developed and described in this paper. For this first course in applied mechanics, the authors defined eleven MCOs. The evaluation for each MCO consists of a quiz that is graded pass / fail (by the mastery of subject method). The percent passing on each outcome quiz is the metric for the continuous improvement program. Each student has two chances to demonstrate mastery for each outcome. Traditional evaluation is maintained alongside mastery quizzes to improve student performance and achievement. Traditional evaluation takes the form of homework, mid-term exam and final exam.

The paper will address course development, student reactions, student success and improvements to the course. A presentation of the course continuous improvement process when using the HEAD Method will also be included.

Introduction

One of the challenges associated with development of continuous improvement processes to meet TC2K Criteria is the difficultly in establishing relevant metrics embedded within courses which are manageable, measurable, and valid. McGourty[1] defines the measurement process into formative and summative measurements. Formative relates to measurements taken during the process which provides real-time feedback, with real-time improvements occurring. Conversely, summative measurements are data collection tools which are measured after the course is complete. Furthermore, McGourty[1] divides measurements into two categories: traditional (standardized exams, direct observation, etc.) and alternative (self assessment papers, portfolios, etc.). The authors chose to provide a hybrid measurement process whereby both a summative, traditional means of measurement and a formative method via the mastery quizzes are employed in the continuous improvement process for the applied mechanics course.

The issue then becomes how can each individual objective be directly measured and assessed free from biased opinions, and/or grade inflation? One approach is to remove partial credit from the evaluation/assessment. The results can be viewed as correct or not correct, or in other terms, pass-fail. Embracing the pass-fail approach to mastery, the authors embarked on a mastery of subject approach for a significant component of the course.

Class Development

Mastery of subject courses are based on learning outcomes and evaluated on a pass-fail basis. The mastery of subject evaluation method requires the student to meet a standard of excellence as it pertains to completing course objectives; in this model, "correct" answers are passing, anything other than "correct" are failing. The number of objectives completed is then evaluated as the basis for the final grade in the class. Davis and Sorrell[2] explain "The goal of mastery learning is success for the student. It is asserted that success in achievement, attitude, and motivation in the education or learning environment makes learning more effective." Mastery of subject is easily explained by an example. Two students take a class; one student is evaluated with traditional methods (partial credit) and understands 75 percent of each class topic covered, with no topic fully understood. While the other student fully understands 75 percent of the topics covered in the class. Both students receive a 75 percent for the final grade; however, the mastery of subject student possesses the prerequisites needed for future success. It should be noted, although mastery of subject allows for the student learning to be self-paced, the authors believe improved student performance is achieved when reasonable time constraints are applied.

There are, however, issues that arise with the mastery of subject approach: for instance, how many outcomes can be tested during a semester? And is a pass-fail evaluation fair to the student? In order to mitigate some of these issues, the authors extend a compromise between mastery of subject and traditional evaluation methods.

For purposes of grade distribution, the class was divided into percentages as follows: mastery of subject 40% and traditional evaluation 60%. Based upon this allocation some acceptable student performance on the MCOs would have to occur in order for a student to pass the course.

In developing the course outcomes, three factors were considered: 1) what are the required prerequisite topics, 2) what is the student expected to know after completing an applied mechanics course, and 3) how many quizzes can be effectively delivered during a sixteen week semester. After much discussion and debate, the authors settled on eleven MCOs for the course. They were, in no particular order of importance, as follows:

- ***Quiz #1***- *Measurable Course Outcome: Determine the location of the centroids of composite areas. (Blooms taxonomy - Knowledge, Comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #2*** *- Measurable Course Outcome: Determine the area moment of inertia of built-up sections that are encountered in "real world" engineering. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #3*** *- Measurable Course Outcome: Understand basic engineering mechanics principals (Blooms Taxonomy – Knowledge and comprehension; ABET Criterion 1.a)*

- ***Quiz #4*** *- Measurable Course Outcome: Determine the resultant of several concurrent forces. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #5*** *- Measurable Course Outcome: Determine the moment of a force. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #6 -*** *Measurable Course Outcome: Determine the resultant of a non-concurrent force system. (Blooms Taxonomy - Analysis; ABET Criterion 1.f)*

- ***Quiz*** *#7 - Measurable Course Outcome: Determine the force necessary for static equilibrium of a rigid body subjected to a number of known forces. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #8*** *- Measurable Course Outcome: Calculate internal forces in members of simple structures. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #9*** *- Measurable Course Outcome: Calculate the reactions for simple frame structures. (Blooms Taxonomy - Comprehension and Analysis; ABET Criterion 1.a, 1.f)*
- ***Quiz #10*** *- Measurable Course Outcome: Determine output loads of machines. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

- ***Quiz #11*** *- Measurable Course Outcome: Evaluate basic problems involving dry friction. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

Each MCO was further divided into "skill sets" to provide the student with a road map for success on each quiz. For example:

- ***Quiz #8*** *- Testable Learner Objective: Calculate internal forces in members of simple structures. (Blooms Taxonomy - Knowledge, comprehension, and Analysis; ABET Criterion 1.a, 1.f)*

  Skill Sets Required for Quiz #8:
  1) *Define external and internal forces*
  2) *Define ideal truss (simple truss)*
  3) *List assumptions for truss analysis*
  4) *Perform check of static determinacy and stability for a truss*
  5) *Recognize zero force members in an ideal truss*
  6) *Perform method of joints for truss analysis*
  7) *Perform method of sections for truss analysis*

By providing skill sets, students may readily understand what areas require attention if the MCO is not mastered on the first trial of the quiz. Due to the fact that each MCO quiz could be taken twice (with different problems), the student could focus on their weak areas and have success the second time they took the quiz. The students were afforded three chances to prove mastery of subject for any given MCO, two in the form of quizzes and once on either the mid-term exam or the final exam (not comprehensive). The only stipulation for success was a complete, correct answer in order to receive credit. Completeness accounted for direction of forces, units, and the answer with all supporting calculations present. Each quiz was given equal weight.

The traditional evaluation portion of the course was further divided into three equal sections: homework, mid-term exam, and a final exam. It should be noted that the final exam was not comprehensive, covering material after the mid-term exam. Each section was worth twenty percent of the final grade and partial credit was awarded.

Continuous Improvement Program

The continuous improvement program was a function of the Measurable Course Outcomes and student evaluations. To be specific, the class average for each MCO was the statistical metric for assessment. Figure 1 illustrates the continuous improvement process at the class level.

The typical success rate in applied mechanics at Fairmont State University is approximately 45-55 percent. Success for this experiment is defined as percent progression, or percentage of students achieving a grade of "C" or better. Therefore, in consideration of the historical data, a target of 65 percent was established as the initial target rate for each MCO. With regard to the continuous improvement aspect of the course, each MCO class average would be assessed against the 65 percent. Those not meeting the 65 percent average would have an action plan for improvement created by the faculty. The plan for improvement would address the MCO which did not meet the defined goal, identify issues arising from the student evaluations, failures in the skill sets identification, and recommend an alternative or innovative approach for presenting the MCO to the class.

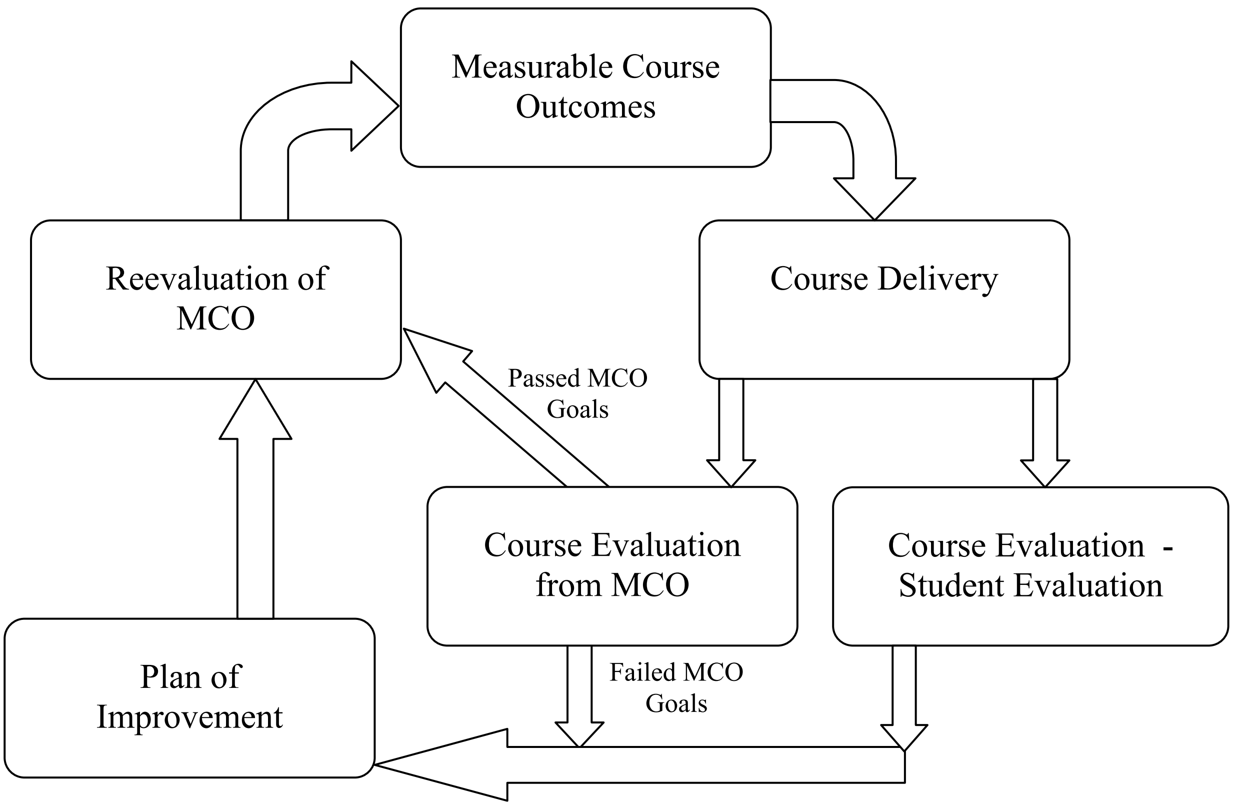

Figure 1. Continuous Improvement Flow Chart at the Course Level

For MCO class averages which met the defined goal of 65 percent passing, the defined goal (65%) was evaluated and re-adjusted based on the class performance statistics.

Student Reactions and Performance

The primary goal of the development was to create metrics that allowed direct measurement of the course objectives. The mastery of subject approach provided an environment that allowed for self-paced learning while defining standards of excellence.

At the start of the semester, students voiced support for the course structure. However, it was readily apparent as the course progressed, many students did not fully believe that the pass-fail standard would prevail. After the first and second quiz, a number of students pleaded their case of being very close to mastery, expressing feelings that their efforts should somehow count, perhaps as partial credit. Once the students embraced that the mastery of subject was permanent and nonnegotiable, there was a noticeable increase in effort (although total support for the course structure was declining somewhat after the first two quizzes). Students frequently visited the professor during office hours, more meaningful interactions took place during class, and class performance on homework improved significantly. The students began to take full, personal responsibility for performance. A final analysis of student acceptance was conducted with personal interviews and through the student course evaluation. The majority of students believed the approach to be valid. Typical student comments on the end of course evaluations follow:

"I would refer to the course as forced learning. While the course was a lot of work, the pass/fail option forced me to study and be prepared for class."

"I thought the quizzes really prepared me for the exams, I did not need to study as much."

"Great course, great teacher, I really know statics."

"the pass/fail portion of the course made the course much harder that it needed to be."

Student perceptions on the end of course survey were favorable. The course received 4.3 out of 5.0 on the question, *I worked harder in this class than on other courses I have taken*. Overall, from the student evaluation, the instructor was rated at a 4.3 out of 5.0 and the excellence of the course was given a 4.1 out of 5.0.

A section of the course which did not employ the MCO approach is used for comparison. The experimental MCO course had a beginning enrollment of 30 students and Control Course X (non-MCO approach) had a beginning enrollment of 35 students. Control Course X gave compatible quizzes and exams as in the MCO course. As shown in Table 1, the MCO course performance shows improvement over the Control Course X on quiz performance, percent passing, and the exam performances for both courses. Significantly, the MCO Course quiz performance indicates mastery while the Control Course signifies mean scores with partial credit considered.

Table 1. Quantitative Course Comparison

	MCO Course	Control Course X	Difference %
Retention	86.67%	58.25%	28.42%
Percent Passing Course (with "C")	70.00%	51.00%	19%
Overall Class Quiz Performance	70.80%	58.60%	12.20%
Midterm Class Average	70.30%	61.20%	9.10%
Final Average	72.65%	60.4	12.25%

Conclusions and Recommendations

The MCO approach shows promise. A second generation of this approach is being developed for delivery utilizing lessons learned from the pilot offering. The authors believe this approach did assist students in mastery of topics. Students appeared to take more responsibility for their learning in the mastery (pass/fail) environment. The authors will be looking to implement the HEAD approach in other courses if the second generation offerings yield similar results.

The authors recognize that other factors may contribute to the results. One such contributing factor could be ACT Scores. The authors did an evaluation to see if there would be any correlation between the MCO success and ACT scores. The average ACT scores of the group in the Control Course X group was a 21.42 in math and a 20.12 overall. Interestingly, the average ACT score for the MCO experimental group was an 18.44 for math and a 19.32 overall. The Control Course X group had higher ACT predictors for success than the MCO experimental class. Regardless, due to the relatively small size of the two data sets, additional data is needed to unequivocally validate the results of the HEAD Approach.

From a faculty standpoint, the required time to manage such a course is an issue, mainly due to delivering multiple quizzes for each MCO. In order to reduce the actual time delivering quizzes, an online delivery format is being explored. This would require the creation of a quiz bank (multiple problems) for each MCO. Additionally, online quizzes would allow students to proceed at their optimum learning pace, within reasonable time constraints, while affording multiple attempts at mastery.

The HEAD Method experiment provided a viable approach to continuous improvement at the course level. A direct measurement of specific course objectives allows the faculty member to better identify problem areas of learning. As a result, the instructor can focus efforts on identified areas needing improvement. In turn, course improvements can occur, and ultimately, student success rates should improve. For the entry level applied mechanics course, some topical areas showed lower student success on the MCOs and will require improvement to provide the student an opportunity for success. A plan for improvement has been implemented to reach the defined goal of 65 percent for the two objectives which did not meet this threshold. The modified objectives and quizzes will be evaluated in the second generation offering.

Bibliography

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