Enhancing Student Learning Through Self-Assessment

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Abstract - First year engineering courses at Michigan Technological University have instruction and activities that address students’ various learning styles. Traditionally, these courses have focused on increasing active learning through in-class examples, team exercises and design projects. Despite these activities, there have been several course topics where the students continue to have difficulty applying the principles to an engineering problem. To address this issue, in the fall of 2007, self-assessments were introduced to enhance the resources available for students. The assessments were a series of non-graded questions designed for students to explore the course topics in greater detail on their own time. As this was not part of the overall course requirements, student participation was voluntary. The questions applied lecture material to real world applications. The self-assessments were administered through Blackboard CE. Students were able to log into Blackboard, complete the assessment and receive immediate feedback regarding their performance. To enhance their understanding of the material, they could repeat this process multiple times. This paper will discuss student responses to this learning approach as well as assessment data to determine the effectiveness of this method as a teaching tool.

Index Terms – Assessments, Blackboard, Engineering, First-Year Programs

BACKGROUND

Since the inception of the common first-year engineering program at Michigan Technological University in 2000, course material has been taught using active, collaborative teaching methods. This approach improves the dynamic of the classroom and student participation. Despite this method, it was apparent that students continued to have difficulty applying course material to engineering problems on several course topics. These topics included empirical functions, ethics and Visual Basic (VBA) programming. For the majority of the students, engineering ethics and programming were new concepts. Without prior knowledge of these topics, the customary lecture/activity sequence did not help the students extend their understanding of these topics to address complex engineering problems. Clearly, another learning method for these subjects was needed. However, time and material constraints on the course would not permit additional class time devoted to these topics without decreasing student learning in other areas.

In order to meet the needs of all the students, alternative learning tools were investigated. Of primary interest was the use of teaching methods that allowed for independent learning and/or investigation of course topics. It was found that for many subjects (i.e. physics and math) there were assessment tools that provided an on-line database of questions for students to access and explore on their own time. These resources were limited because the students did not receive feedback on their work. In order to correct this, several instructors at Tecnológico de Monterrey created an on-line database to provide feedback to physics students to indicate whether they had the correct answers and/or where to find the material they needed to review [1,2]. This idea was included in the first-year engineering program at Michigan Tech for the fall semester in 2007.

DEVELOPMENT OF THE ENGINEERING DATABASE

At Michigan Tech, the first-year engineering program consists of two courses: ENG1101 (Engineering Problem Solving and Analysis) and ENG1102 (Engineering Modeling and Design). Blackboard CE [3] is used to provide course information to the students such as announcements, assignments and grades. This system also allowed the creation of a database of questions that students could access in the form of assessments. Key features desired for these assessments were that: a) the students would be able to review course material outside of class, b) students would be able to receive feedback on their work and, c) course material could be extended to apply to “real-world” examples.

According to Organero and Kloos, there are two types of assessments that can be used: self-assessments and grade-oriented-assessments. Both of these assessment types have been used as motivational tools for e-learning. In general, for grade-oriented-assessments, students were more motivated to complete them when the assessments represented a significant percentage of their final grade. [4] The assessments created for first-year engineering students at Michigan Tech were designed as self-assessments. This allows students to explore course topics in greater detail on their own time. Students are able to log into Blackboard, complete the assessment and receive immediate feedback regarding their performance. To enhance their understanding of the material, they could repeat this process multiple times. Through the use of self-assessments,

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students were able to detect the points they knew and what they did not know in order to focus their study time appropriately. [4]

The first assessment created was to expand student knowledge on empirical functions. In class, students learned to calculate the equations for linear, power and exponential functions using the first and last data point of a given data set. Topics covered in the assessment were the general formulas and graphing of linear, power and exponential functions. The assessment format was fill-in-the-blank, matching, and multiple choice questions. An example view of the assessment is shown in Figure 1. In this screen, students are provided with the questions and are able to see which questions they have answered and can check their answer for each question.

Additional assessments were created to show engineering applications which included: urban planning, cancer research and bungee jumping. For urban planning, students predicted the population growth of an urban center given an exponential function. Students projected the incidence of melanoma for given ozone concentrations using data modified from the Michigan Tech version of Engineering: Fundamentals and Problem Solving [5].

For the bungee jumping example, students determined the empirical function that represented the cord stretch based on the weight of the jumper. Using this equation, they could check their calculation of bungee cord stretch for a person 5’9” tall with a mass of 180 pounds. The assessment screen for this calculation is shown in Figure 2.

The results screen shows the student response and the correct answer. It also provides the most common variations on the solutions. For example, students were asked to input the units for the stretch of the bungee cord. The correct answer was “feet”, but students could also enter “ft” and that would be marked as a correct response as well. If the student’s answer is incomplete or incorrect, this screen provides the student with feedback. In this case, general feedback for the students tells them to use the linear equation they already calculated. The hint is that it should be in the form of $y = mx + b$.

A quick poll of the students after implementation of the empirical functions assessment indicated a favorable response and additional assessments were developed to cover further course topics. A complete listing of the assessment categories and topics can be found in Table I.

![Figure 1: Typical Assessment Question as it Appears on Blackboard CE](image)

**Figure 1**

**TYPICAL ASSESSMENT QUESTION AS IT APPEARS ON BLACKBOARD CE**

Visual Basic topics expanded students’ knowledge on basic programming and debugging techniques as well as investigated functions and object oriented programming (OOP) statements. For example, students were given several examples of visual basic code in which there were errors and asked to identify the error and how to fix it.

For the ethics assessment, students investigated why engineers study ethics and the duties of a professional engineer. Students also analyzed three ethics case studies. These case studies were taken from a listing of case studies previously used in ENG1101 [6]. An example question from the ethics assessment can be seen in Figure 3. This case study dealt with a faulty relief valve on an infant respirator and the dilemma facing the engineer who discovered the problem. Students had to identify the affected parties in the case, the rights and responsibilities of the affected individuals, and the major NSPE Cannons and Ethical Evaluation tests that could be used to defend the engineer’s position.

![Figure 2: Screen Capture of Assessment Results Screen](image)

**Figure 2**

**SCREEN CAPTURE OF ASSESSMENT RESULTS SCREEN**

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In order to evaluate the effectiveness of these self-assessments, students were asked to complete a survey at the end of the semester. Approval was obtained for this survey from Research Services (Internal Review Board, IRB) at Michigan Tech as human subjects were involved. As such, only the data from those students who completed the survey and agreed to participate were analyzed and reported. As the survey was not part of the overall course requirements, student participation was voluntary. The assessments were administered to 3 sections (153 students) of ENG1101 out of 13; 77 students completed the survey, a response rate of 50%. Of these students, 14 did not complete any assessments and 5 did not complete all of the assessments.

To begin, students were asked to rank their knowledge on the course topics on a scale of one to five (1 = Poor, 5 = Proficient) before taking ENG1101, after covering the lecture material and after taking the assessments. The results from the first three questions where students ranked their knowledge throughout the course are presented in Table II. For most of the students, ethics and visual basic were topics introduced for the first time in ENG1101 and are, therefore, ranked the lowest throughout. (Students had completed empirical functions in their previous math courses or in Calculus at Michigan Tech.)

<table>
<thead>
<tr>
<th>Course Timing</th>
<th>Empirical Functions</th>
<th>Ethics Case Studies</th>
<th>Visual Basic (VBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Lecture</td>
<td>3.12</td>
<td>1.32</td>
<td>1.85</td>
</tr>
<tr>
<td>After Lecture</td>
<td>4.08</td>
<td>3.24</td>
<td>4.03</td>
</tr>
<tr>
<td>After Assessment</td>
<td>4.46</td>
<td>3.71</td>
<td>4.44</td>
</tr>
</tbody>
</table>

Looking at the responses, students perceive an increase in their knowledge after both the lecture and completing the assessments. For empirical functions, there was a 24% increase from the lecture material and a 9% increase from the assessment. Overall, there was a 33% increase in self-reported knowledge of this area. The ethics cases showed a 59% increase from the lecture and 13% from the assessment. The Visual Basic topic showed a 54% increase from the lecture and 9% from the assessment. It is interesting to note, however, that despite little to no previous knowledge of Visual Basic before ENG1101 as compared to empirical functions, both these topics were generally ranked the same after the lectures were completed. This trend could be seen as support for the active learning activities during the engineering class itself.

As part of the same survey, students were asked to identify the number of times they completed the assessments. As shown in Figure 4, students that did not utilize the assessments ranked their knowledge higher before ENG1101 than those who used the assessments. Those students who utilized the assessments the most (two to four times) had the lowest incoming perception of their knowledge, but also the highest ranking perception after completing the assessments. It is interesting to note that regardless of initial perceptions, after the lecture material, all groups perceived their knowledge to be relatively equal to the other groups.

Continuing with the survey, the next four questions used a 5-point Lickert scale to indicate whether or not students felt that the assessments were helpful, led them to a better understanding of the course material, a better grade on the material, and a better overall grade in ENG1101. These results can be found in Table III.

In general, the response to the assessments was positive. Overall, students that participated in the assessments completed them more than once (an average of 1.5 times). They agreed that the assessments were helpful and felt that they led to a better understanding of the course material and a better grade on that material. Students were less positive about seeing benefits toward their overall grade, but still indicated a positive response. The ethics case study assessment was ranked the lowest throughout. This could be
primarily attributed to the fact that ethics are a gray area for many students and there is no easy correct/incorrect response. Therefore, the assessment could only serve as a guide to ethical decision making, not give students the correct decision for every ethical scenario.

**TABLE III**

<table>
<thead>
<tr>
<th>Engineering Topics</th>
<th>Assessments were helpful</th>
<th>Led to Better Understanding of Material</th>
<th>Led to Better Grade on Course Material</th>
<th>Led to Better Overall Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical Functions</td>
<td>4.28</td>
<td>4.23</td>
<td>4.18</td>
<td>3.98</td>
</tr>
<tr>
<td>Ethics Case Studies</td>
<td>3.98</td>
<td>4.02</td>
<td>3.87</td>
<td>3.69</td>
</tr>
<tr>
<td>Visual Basic (VBA)</td>
<td>4.43</td>
<td>4.31</td>
<td>4.17</td>
<td>3.92</td>
</tr>
</tbody>
</table>

There was a place in the survey for student comments. Overwhelmingly, the students’ response was positive. Some examples included the following:

- “I really liked the assessments. Even if I already knew the stuff it was a really good way to review and study.”
- “I really didn’t use the assessments until studying for the final exam, but I wish I had.”
- “I really liked the concept of having the online assessments, especially ones which are available for unlimited time. I feel the idea behind them is solid and is a very good study tool.”
- “The self-assessments are an excellent idea because the pace of the course was very rapid. Some of the material can only be understood through repetitive practice. The self-assessment allowed this to occur.”
- “The assessments helped me know if I was doing the material right and what I need to study more.”

A few students commented on improvements needed to make the assessments more helpful. For example, for many of the questions, the instructor entered the correct answer, but the student entered in a variation of that answer and was marked as incorrect (i.e. instructor = .928, student = 0.928). Using the knowledge from this first iteration of the assessment, the instructor will reduce this problem. Students commented that the assessments should be made available before the exam. In the fall of 2007, the Visual Basic and ethics assessments were only created after the second exam when it was determined there needed to be more review on these subjects. In the future, these assessments will be available when the topics are covered in the semester.

**STUDENT PERFORMANCE**

In order to translate the qualitative data on student perception and course performance into quantitative results, the students’ midterm and final exams were reviewed to determine whether or not the assessments had a positive effect on their grade (both the assessment material on the exams and the overall grade in ENG1101). The exam results are shown in Table IV.

In general, the empirical functions assessment showed the greatest difference between students who had not completed the assessment and those who had. The students that completed the assessment scored an average of 15% higher on both the midterm and final exams. This could be attributed to the fact that the empirical functions assessment was available before the midterm and students used it as a study resource. The ethics case study and Visual Basic assessments were not available until after the midterm. After these assessments were posted, the students that completed them scored on average 12% better on the ethics portion of the final and 6% better on the Visual Basic portion.

**TABLE IV**

<table>
<thead>
<tr>
<th>Engineering Topics</th>
<th>Effect of Self-Assessments on Student Performance (Exam Grades as Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical Functions</td>
<td>Midterm Exam: 54%, Final Exam: 73%</td>
</tr>
<tr>
<td>Ethics Case Studies</td>
<td>Midterm Exam: 69%, Final Exam: 88%</td>
</tr>
<tr>
<td>Visual Basic (VBA)</td>
<td>Midterm Exam: 65%, Final Exam: 76%</td>
</tr>
</tbody>
</table>

After analyzing the data and looking at student perception, two questions resulted:

- Did the students’ perception match their academic performance?
- Did the number of times a student completed a given assessment impact their overall performance?

The solutions to these questions on student performance in the assessment material on the exams and overall grade in ENG1101 are shown in Figure 5. Those students who utilized the assessments scored better on the assessment material on the exams. There was a 6-8% increase in midterm exam score and a 7-13% increase in final exam score for those students who completed the assessments at least once as compared to those who had not used the assessments. This corresponded to results from the physics on-line database developed at Tecnológico de Monterrey. [2] It is interesting to note that the students who used the assessments more than once did not do as well on the assessment material as those students who used the assessments only once.
These results fit with the two types of students observed by Organero and Kloos: those interested in learning and those interested in passing the subject. In general, students interested in passing the subject are more assessment-driven and are motivated to complete the assessments more frequently. [4] This increase in motivation, however, does not necessarily translate into learning the material. While these students showed an improvement in their grades compared to the students who did not use the assessment, they were not able to apply the assessment concepts to different situations presented in the exams. However, looking at the overall grades of these students, it appears that those students who used the assessments (regardless of the number of times) collectively earned a 6% higher grade in ENG1101.

A one-tailed t-test was performed to determine the significance of these results. The t-test was performed on the final exam scores for two groups a) those that used the assessment versus those who had not and b) those that used the assessment multiple times versus those who used the assessments only once. The results of the t-test appear in Table V below. Looking at the data, there were only three cases that were statistically significant (p < 0.05). For the empirical functions and ethics assessments, the use of assessments resulted in a significant improvement in final exam grade (p = 0.01 and p = 0.05 respectively). Also, the use of the ethics assessment multiple times resulted in a significant improvement (p=0.01).

Multiple use of the empirical functions assessment did not appear to have a statistically significant benefit for the students (p = 0.3). In addition, use of the Visual Basic assessment did not appear to have significant results on the final exam grade of the students. This could be attributed to several factors. First, those students who did not complete the assessment were probably those students with prior programming experience. Secondly, from student comments, the students found the Visual Basic assessment to be the least helpful with regard to applying the material.

### Conclusions

Some interesting results from this study indicated that the students who did not utilize the assessments ranked their incoming knowledge of the course topics higher than other students. Students who ranked their initial knowledge base the lowest completed the assessments the highest number of times Regardless of initial perceptions, all students perceived their knowledge to be relatively equal after the lecture material.

Looking at the results of this study, students perceived a 9-13% increase in their knowledge on the course material after completing the assessments. This perception is validated as the students completing the engineering assessments scored an average of 7-13% better on the assessment material during examinations. In addition, these students had an average of a 6% higher grade than those students who had not used the assessment tool. Use of the empirical functions and ethics case study assessments indicated a significant improvement in final grade on those topics (p = 0.01 and p = 0.05 respectively).

Student comments indicated a positive response to the assessment tool as well as a few improvements needed to make the assessments more helpful. These comments will be included in future versions of the assessments.

### Future Work

Based on the positive response to these assessments in ENG1101, the concept has been initiated into the second semester engineering class, ENG1102. In this course, the students focus on 3D modeling using UGNX and programming using Matlab. A UGNX assessment was created and administered to the students in three of the eleven sections of ENG1102 (approximately 160 students). A Matlab assessment is planned for the second half of the semester.

In addition, the Visual Basic Assessment will be updated and expanded based on suggestions from the ENG1101 class and administered to a section of ENG1100 (Engineering Problem Solving) in the spring of 2008. ENG1100 is a portion of the pre-calculus version of ENG1101 and covers many of the same topics as ENG1101. Based on the success of these assessments in ENG1100, ENG1101 and ENG1102, this learning method will be expanded to all sections of the first-year engineering program.
REFERENCES


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