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## **AC 2011-210: USING ONLINE ENDLESS QUIZZES AS GRADED HOME-WORK**

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# Using Online Endless Quizzes as Graded Homework

## INTRODUCTION

In an effort to find the best use of limited teaching assistant's time in today's economy, a study<sup>1</sup> reported at ASEE 2010 conference by the last two authors of this paper indicated that there is *no* statistically significant difference in student performance when homework is assigned, collected and graded versus when homework is assigned, and neither collected nor graded. The study was conducted in a Numerical Methods course at University of South Florida (USF) over a period of three years encompassing data from over 300 hundred Mechanical Engineering students, and student performance was measured via an identical multiple-choice final examination.

Today's generation of students are inundated with technological devices that provide them with needed information for daily living as well as socially connecting with their peers. Given the vast integration of technology on one's daily life, it is no stretch to imagine technology at the center of student learning. Faculty are constantly identifying and developing ways to be more inclusive of technological innovations to help students learn new and difficult materials as well as demonstrate learning<sup>2,3</sup>.

Because of the use of course management systems such as Blackboard (<http://blackboard.com>) in most universities and the availability of quiz makers such as Respondus (<http://respondus.com>), we wanted to determine if using graded online quizzes would improve student performance, while minimizing grading time. Although other online homework and grading systems such as WebAssign (<http://www.webassign.net/>) are available, there are substantial recurring costs associated with the use of such systems for both students and faculty. In addition, the availability of engineering topics in these systems is very limited. The online quizzes we developed in this study put no financial burden on the student, and the student uses a familiar interface to take the quizzes.

A comprehensive course in Numerical Methods in Engineering consists of eight to eleven modules:

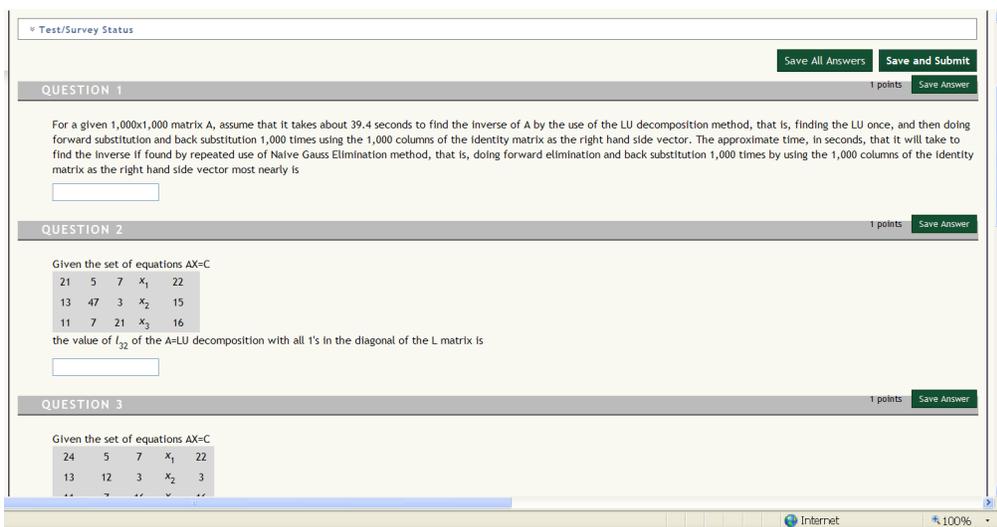
- 1) Introduction to Scientific Computing
- 2) Differentiation
- 3) Nonlinear Equations
- 4) Simultaneous Linear Equations
- 5) Interpolation
- 6) Regression
- 7) Integration
- 8) Ordinary Differential Equations
- 9) Partial Differential Equations
- 10) Optimization, and
- 11) Fast Fourier Transforms.

At USF, the syllabus covers the first eight topics. As a pilot study, we developed endless online quizzes (EOQs) for all the three subtopics of Topic#4: Simultaneous Linear Equations (SLE) taught in the class

- a) Background of Matrix Algebra,
- b) Gauss Elimination and
- c) LU Decomposition.

All quizzes had 6-7 questions, and were of algorithmic form. This form allows the instructor to choose some or all variables to take values within a range, and develop a formula for the correct answer. These formulas were developed by writing scripts with symbolic computation in MATLAB and Maple.

When a student takes the quiz (Figure 1), the system randomly chooses the values of the selected variables, and the student answers the question by filling in the answer field. The student's answer is checked against the correct value. Feedback, including the answer and the correctness of the answer, is given immediately.



**Figure 1:** Endless Online Quiz (EOQ) Interface

The students were given 10 days and unlimited attempts from the day when the first subtopic was introduced in class to complete all the three quizzes. The time given to make an attempt was not limited. The number of attempts, and time taken and the score for each attempt was automatically recorded by Blackboard.

Given that the literature shows that self-efficacy<sup>4,5</sup>, learning with technology<sup>6</sup>, and pre-requisite grades<sup>7</sup> can have an influence on how well students work successfully with given STEM-related concepts, these possible influences are addressed in this paper. We also study the effect of the EOQs on the student performance.

## PURPOSE

Over the past year (2009-2010), faculty in the mechanical engineering department at USF have developed practice tools to enhance students' opportunity to practice critical concepts and increase their academic achievement and retention in engineering degree programs. Specifically, the online practice tool at USF is entitled Endless Online Quizzes (EOQs). The EOQs were created and designed for students in a Numerical Methods course that is pivotal to student success in a given engineering degree program. The EOQs could be accessed online anytime

(within the 10- day open period), anywhere, and both included embedded just-in-time assessments to allow students to know if they were answering problems correctly. This paper is an overview of the outcomes of the EOQs practice tool implemented at USF during the spring and summer semesters of 2010.

To guide the assessment activities for the EOQs anywhere, anytime practice tool, the question for which the instruments and analyses were designed to answer includes:

*To what extent did the prototype EOQ tool enhance student learning and ability to demonstrate greater efficiency in Numerical Methods-type courses that are critical to successful completion of engineering programs?*

To determine to some extent whether or not the EOQs had an influence on students' improvement in learning and demonstration of competency in specific concepts for which the online practice tool was designed to address, the assessments included running analyses to determine if students' learning styles, self-efficacy, learning with technology, or grades in prerequisite courses contributed to their final grade. The purpose of including these characteristics is because research has shown that how well students learn and demonstrate learning can be predicated on their preferred learning style as well as their self-efficacy with learning new concepts—particularly in engineering. Explanations of the analyses are provided in the findings section of this paper.

With regard to the assessment tools designed and used for gathering data that would be analyzed in an effort to respond to the above questions, there were two pre-introduction to EOQs assessments, student transcript data, one post-introduction/use to EOQs, and final examination data that shaped the majority of these findings.

## **METHODOLOGY**

The methodology used to gather, analyze, and report the findings of the data included administering assessment tools, tracking student performance in the Numerical Methods course, identifying student performance in prerequisite courses, and engaging in a focus group conversation about the students' experience with the online EOQs practice tool. Specific statistical procedures and analyses are provided in the findings section of this report. This section contains an overview of the assessment used for this project.

### The Assessment Tools:

*Learning Combination Inventory:* Prior to introducing the students to the EOQs, two assessments were administered to the students. This was done in an attempt to control for any characteristics that would form the students' profile and result in an influence on learning. The first assessment included the *Learning Combination Inventory* (LCI) developed by [8]. The LCI is divided into two parts and includes 28 questions in part one that allows the respondent to rate their preference for learning patterns. These learning patterns are reflected in the literature regarding obtaining, retaining, and retrieving learned information. The response options are presented on a 5-point Likert scale of:

- “Never Ever = 1,”
- “Almost Never = 2,”
- “Sometimes = 3,”
- “Almost Always = 4,” and

“Always = 5.”

Part II of the LCI includes three (3) open-ended questions that allow respondents to write—in their own words—their thoughts regarding their preferred approach for completing certain types of assignments. The quantitative portion of Part I (Q1-Q28) and the qualitative data from Part II are combined to provide students with a score for each of the four patterns identified in the instrument. The lower the score (i.e., 7-17), the greater the likelihood the respondent avoids that particular pattern. Concomitantly, the higher the score (i.e., 25-35), the greater the likelihood the respondent uses that pattern first. Middle scores (18-24) indicate that the respondent uses the pattern as needed without regard to preference. These patterns include

1. Sequential Processing,
2. Precise Processing,
3. Technical Processing, and
4. Confluent Processing.

*Self-Efficacy:* The second assessment was a customized survey designed by an external evaluator on self-efficacy in learning in general, learning with technology, learning difficult materials, as well as discussing materials with which students are unfamiliar. The questions on the survey were developed from the literature of Bandura<sup>4</sup>, a clinical psychologist on efficacy, self-efficacy in learning, and efficacy in learning science and mathematics. Specifically, each question allowed the respondents to indicate their level of ability to complete several learning activities on a scale of 1 – 7 with one representing low self-efficacy (*Not well at all*) and seven representing high self-efficacy (*Very well on my own*). Part I included 10 questions with 7 as the highest score, which is indicative of a higher self-efficacy. Therefore, a score between 10 and 23 represented low self-efficacy, a score between 24 and 46 represented medium self-efficacy, and a higher score of 47 – 70 represented a higher self-efficacy. Part II of the self-efficacy survey included questions regarding students’ frequent use of technology and the reasons for their use.

*Tracking Attempts with EOQs:* Tracking the number of attempts students made in solving problems with the EOQ tools as well as the amount of time a student remained logged into the environment until getting the correct answer to the problem(s) was used in this analysis.

*Focus Group:* After students engaged in using EOQs, a sample group participated in a focus group via conference call. The students responded to seven (7) questions specific to their experience with EOQs. The focus group conversation began with a very brief introduction of the overall purpose as well as brief introduction of the facilitator. All participants were informed of the need to be open and honest about their responses in an effort to have a realistic influence on the effectiveness of the EOQs online practice tool to inform the research of the project investigators.

*Simultaneous Linear Equations (SLE) Score:* Although students completed a 32- question multiple-choice final examination based on the eight topics in the Numerical Methods course, the EOQs was designed to assist the students only with Simultaneous Linear Equations topic by working problems on subtopics of Background of SLE, Gauss Elimination, and LU Decomposition. The students’ final SLE score (maximum of 4) was used throughout the analyses as the dependent variable.

After the students completed the pre-assessments, they were introduced to the EOQs online practice tool. The post assessment was their feedback during the focus group. Specifically, the quantitative data included learning style variables, self-efficacy variables for the individual questions, and grades students earned in prerequisite courses. Results from the frequent use of technology were not analyzed with these data. The research questions that guided the analyses are given in Table 1.

**Table 1:** Research questions to guide the data analyses

<b>Research Question</b>	<b>Type of Data Gathered</b>	<b>Semester Gathered</b>
1. Student learning styles have no effect on academic achievement.	<ul style="list-style-type: none"> <li>• LCI Survey</li> <li>• Final Course Grades in Numerical Methods</li> <li>• SLE Score</li> </ul>	Spring 2010 Summer 2010
2. Student self-efficacy has no effect on academic achievement	<ul style="list-style-type: none"> <li>• Self-Efficacy Survey</li> <li>• Final Course Grades in Numerical Methods</li> <li>• SLE Score</li> </ul>	Spring 2010 Summer 2010
3. Students' grades in prerequisite courses have no affect on academic achievement	<ul style="list-style-type: none"> <li>• Student grades in 4 prerequisite courses required for enrolling in Numerical Methods.</li> <li>• SLE Score</li> </ul>	Spring 2009 Summer 2009 Spring 2010 Summer 2010

To identify whether or not the above research questions would be accepted (meaning that the students' learning styles, efficacy, and grades in prerequisite courses had no effect on students' academic achievement in the course) or rejected (meaning that one or more of the above assessments had some influence on students academic achievement), a simple linear regression was administered on four sets of data whereas each set entered the model in the order provided below.

***Data Set #1 (Learning & Efficacy)***

<b>Independent Variable(s)</b>	<b>Dependent Variables</b>	<b>Statistic Method</b>
Self-Efficacy Score Precise Sequential Technical Confluence	SLE Score	Regression

***Data Set #2: (Demographics)***

<b>Independent Variable(s)</b>	<b>Dependent Variables</b>	<b>Statistic Method</b>
Age Transfer Race/Ethnicity (2010 Only) Gender (2010 Only)	SLE Score	Regression

***Data Set #3: (Prerequisite Courses)***

<b><u>Independent Variable(s)</u></b>	<b><u>Dependent Variables</u></b>	<b><u>Statistic Method</u></b>
Calculus #1 Grade	SLE Score	Regression
Calculus #2 Grade		
Calculus #3 Grade		
ODE Grade		

***Data Set #4 (EOQ Concept Scores on First Attempt)***

<b><u>Independent Variable(s)</u></b>	<b><u>Dependent Variables</u></b>	<b><u>Statistic Method</u></b>
Background Score	SLE Score	Regression
Gauss Elimination Score		
LU Decomposition Score		

In addition to these regression analyses, a bivariate correlation matrix on all variables for all four semesters (spring and summer 2009 and spring and summer 2010) was conducted as well. These correlations allowed for interpretation of connections between variables in addition to the regression relationship with the dependent variables of SLE scores and on the Numerical Methods final course grade. The findings from the bivariate correlation matrix were used to inform the findings as opposed to the correlation in the regression model because the regression model utilizes a one-tailed test while the bivariate correlation model utilizes a two-tailed test. The regression with SLE score as a dependent variable and Numerical Methods final course grade were run separately.

The purpose of a linear regression is to determine whether there is a relationship or association between variables as well as determine the extent to which one variable explains the variance in the other.

**FINDINGS**

The findings from the regression analyses of the above data sets revealed weak to moderate relationships on only a few of the variables. There was a negative moderate relationship between Calculus #3 and the SLE Score (-0.436) with a significant ANOVA of the regression model indicating that these relationships did not occur by chance.

**Profile of the Students**

To contextualize any findings that may be associated with success in the course, students completed a learning patterns survey before beginning the two of the four semesters - spring 2010 and summer 2010. In addition, during the spring and summer of 2010, students also completed a self-efficacy survey to measure how well students believed they could learn various subject materials with or without help from others. Although providing a measure for students' preference for learning and self-efficacy may or may not have an influence or correlate with the grades received in the course or performance on exams and quizzes, it is helpful to attempt to control for these variations to determine whether or not the EOQs make a difference in student success regardless of learning style or level of self-efficacy. Finally, including this information provides an overall context in which any findings should be interpreted regarding the effectiveness of the EOQ online practice tool.

*Spring 2009:* (No pre-assessments were performed)

During the spring 2009 semester, 42 students enrolled in the Numerical Methods course. The academic profile of the class revealed that over 75% of the students had a grade of A or B in their prerequisite courses which included Calculus 1, Calculus 2, Calculus 3, and ODE. In addition, 90% were male and 10% were female; 71% of the students were between the ages of 21 and 23; 53% were first time college students with 47% being transfers from a community college or other institution. At the end of the semester, 79% of the students earned a grade of B or higher in the course and 22% earned a grade of C or lower.

*Summer 2009:* (No pre-assessments were performed)

The academic profile of the 70 students enrolled in the Numerical Methods course during the summer was slightly similar to the academic profile of the spring 2009 students in that over 60% earned a grade of B or higher in all pre-requisite courses. Again, the majority were male students at 87% with 13% identifying as female; and 50% of the students were between the ages of 20 and 23. With regard to transfers, 37% were first time students and 63% were transfers from the community college or other institution. At the end of the semester, 56% of the students earned a grade of B or higher in the Numerical Methods course.

*Spring 2010:*

With regard to the students' academic profile for spring 2010, over 63% of the 63 students enrolled in the Numerical Methods course earned a grade of B or higher in their prerequisite courses; 94% were male and 6% were female; 79% were between the ages of 20 and 23; and 49% were first time students with remaining 51% being transfers from the community college or other institution. Also similar to the previous two groups, 56% earned a grade of B or higher at the end of the Numerical Methods course.

In addition to the academic profile, the spring 2010 students enrolled in Numerical Methods completed several assessments prior to (learning and efficacy), during (tracking attempts at EOQs), and after (focus group) completing the course. With regard to learning patterns, the majority of the students had a higher preference for certain learning patterns. Specifically, for spring 2010, there were 63 students enrolled in the Numerical Methods class, however, 21 students did not complete the self-efficacy survey, and nine (9) students did not complete the learning pattern assessment. However, the findings are for those students who completed the given assessments of discussion.

*Summer 2010:*

The academic profile of the student population enrolled in the course during the summer of 2010 revealed similar results as the previous summer (2009) in that between 67% and 78% earned a grade of B or higher in their prerequisite courses. However, at the end of the course only 39% of the students earned a grade of B or higher in the Numerical Methods course. Similar to the spring 2010 students, the 70 students enrolled in the summer 2010 completed pre-assessments that were administered to control for any differences that might occur as a result of using the EOQ. Of the 70 students, six (6) students did not complete the self-efficacy survey and 11 students did not complete the learning patterns assessment.

Utilizing frequencies statistics, overall, the student profile revealed that the majority of the students for spring 2010 had a higher preference for precise and technical processing patterns and a medium preference for the confluent processing pattern. With regard to self-efficacy, the highest composite score for self-efficacy was 66 (out of a maximum of 70) and the lowest was 21 (with the minimum being 10). In terms of pre-requisite grades, the majority of the students earned a grade of C or better in all four prerequisite courses with two-thirds of the students earning a grade B or better. Only a very small percentage earned a grade of D.

The profile of the students who enrolled in the summer 2010 Numerical Methods course was similar to the profile of the students in the spring 2010 class (See Table 2). Most of the students enrolled during the summer completed the assessments assigned to the project regarding learning patterns and self-efficacy. Overall, the majority of the summer 2010 students identified a higher preference for the sequential, precise, and technical learning patterns and a medium preference (meaning to use as needed) for the confluent learning pattern. With regard to self-reported self-efficacy, over half (69.1%) indicated a high self-efficacy. In terms of prerequisite course grades, the majority of the students passed each of the prerequisite courses with a C or better with over half earning a B or better.

The profile of the students for spring and summer 2010, with regard to learning styles, self-efficacy, and prerequisite course grades is provided in Table 2.

**Table 2:** Profile of the Spring 2010 and Summer 2010 Numerical Methods Course at USF.

Learning Style	Variables	Spring 2010			Summer 2010		
		High	Med	Low	High	Med	Low
Learning Style	Sequential Processing Pattern	53.7%	40.7%	5.6%	54%	39.7%	6.3%
	Precise Processing Pattern	63%	37%	0%	61.9%	38.1%	0%
	Technical Processing Pattern	85.1%	13%	1.9%	90.5%	9.5%	0%
	Confluent Processing Pattern	29.6%	64.8%	5.6%	42.9%	52.3%	4.8%
Self-Efficacy	High Self-Efficacy	50%			69.1%		
	Medium Self-Efficacy	50%			27.9%		
	Low Self-Efficacy	0%			2.9%		
Academic		A(+/-)	B(+/-)	C(+/-)	A(+/-)	B(+/-)	C(+/-)
	Calculus 1	42.9%	30.1%	27%	46.6%	31.5%	20.5%
	Calculus 2	41.3%	22.2%	36.5%	30.1%	37.0%	32.9%
	Calculus 3	38.1%	34.9%	27%	30.1%	41.1%	27.4%
	ODE	41.3%	38.1%	20.6%	31.1%	40.5%	27%
Demographics	Male	94%			91%		
	Female	6%			9%		
	Sophomore	0%			0%		
	Junior	24%			25%		
Senior	76%			75%			

### Relationships among Variables

To determine whether student learning patterns, self-efficacy, or the students' grades from prerequisite courses had any effect on students' final grade in the Numerical Methods course or their SLE scores, correlation matrix and linear regression were used. The correlation matrix revealed which variables correlated at a level of significance, and the regression provided inferences for the relationships among the variables. With regard to the linear regression, each of the variable sets (Learning Patterns; Self-Efficacy composite scores; and Pre-requisite grades and scores from the students' first attempt at completing a problem on the concepts of Background of SLE, Gauss Elimination, and LU Decomposition) was entered as separate models rather than via stepwise. The reason for not entering the variable sets in a stepwise fashion was to keep the relationship between the like-variables within context. Entering the data sets in a stepwise fashion would modify the model, result in interactions among all the entered variables, and thereby reduce the simplicity of interpreting whether or not separate data sets had a relationship with the SLE score or Numerical Methods final course grade.

**Correlations.** For spring and summer 2010, the correlation matrix of all variables (learning styles, EOQs attempts and time duration, self-efficacy, and pre-requisite classes) revealed both positive and negative correlations but nearly all correlations were weak. However, there were a few variables with weak/moderate correlations (see Tables 3 and 4). The correlation matrix for summer and spring 2009 showed very weak relationships with the students' SLE score and Numerical Methods final course grades.

**Table 3:** Correlations among Variables for Spring 2010

Variable#1	Variable #2	Correlation	Sig (2-tailed)
<b><i>Weak/Moderate Correlation</i></b>			
Age	Numerical Methods Final Grade	.385	.002
ODE	Numerical Methods Final Grade	-.306	.015
Calculus 3	Numerical Methods Final Grade	-.360	.004
Gauss Elimination Score	SLE Score	.308	.014
Self-Efficacy Level	Numerical Methods Final Grade	.323	.037

*Weak/Moderate = 300s; Moderate=400s, 500s, 600s; and Strong = > 600s*

**Table 4:** Correlations among Variables for Summer 2010

Variable#1	Variable #2	Correlation	Sig (2-tailed)
<b><i>Weak/Moderate Correlation</i></b>			
LU Decomposition Score	Numerical Methods Final Grade	.326	.005
Calculus 3	SLE Score	.328	.005
<b><i>Moderate Correlations</i></b>			
SLE Score	Numerical Methods Final Grade	.431	.000

*Weak/Moderate = 300s; Moderate=400s, 500s, 600s; and Strong = > 600s*

**Regression Analyses:** There were two regression analyses performed for these data. The first included the SLE score as the dependent variable and all other variables were independent variables. The second regression included the Numerical Methods final course grade as the dependent variable and all other variables as independent variables. The independent variables for 2009 semesters (spring and summer) included prerequisite scores only (pre EOQ). The independent variables for 2010 included self-efficacy scores, learning patterns, Prerequisite grades, and the EQ scores on each of the concepts of Background, Gauss Elimination, and LU Decomposition (post-EOQ). The regression analyses revealed the following:

- For spring 2009, the correlation matrix resulted in a very weak relationship between SLE score and final Numerical Methods course grades (less than 0.100) in either direction (2-tailed test). A regression analysis revealed a somewhat weak relationship of 0.371 between Calculus 3 and the SLE score, however, this relationship was not significant ( $p$ -value=0.708). With regard to summer 2009, the students' course grade had a positive but moderate correlation with the SLE score (0.536) with a significance of  $p$ -value<0.001. In addition, the Calculus 3 score was positively correlated with the SLE score (0.390) with a significance of  $p$ -value<0.001.

These findings indicated that although there may be a relationship between several of the independent variables (above 0.200), the relationship is still weak suggesting that any success a student has with the SLE portion of their test or completing the course with a grade of B or higher is more likely attributed to some other experience, attribute, or characteristic other than their prerequisite scores. The only prerequisite score that had a correlation coefficient above 0.200 was the Calculus 3 course grade.

- For spring 2010, the relationships between the independent variables and dependent variables in the correlation matrix (relationships above 0.200) revealed the following:
  - Self-efficacy level, Calculus 3 course grades, ODE course grades, and age had a weak positive relationship with the Numerical Methods final course grade.
  - Students' score on the subtopic Gauss Elimination Quiz (1<sup>st</sup> attempt only) had a weak correlation to the SLE score.
- Summer 2010,
  - There was a positive weak correlation between SLE score and Calculus 3 as well as a positive moderate relationship between SLE score and Numerical Methods final course grade.
  - With regard to the SLE concepts, the subtopic LU Decomposition score on the first attempt had a weak positive relationship with the Numerical Methods final course grade (above 0.200, see Tables 3 & 4).
- For the two dependent variables (SLE Score and Numerical Methods final course grade) used to correlate independent variables for **endless quizzes**, these findings revealed that

- The students' final SLE score has a stronger correlation with the students' subtopic Gauss Elimination score on the first attempt than with any of the other concepts—albeit still determined as weak—for spring 2010.
- The subtopic LU Decomposition score had a stronger correlation than the other concepts for the summer 2010 students.
- The Numerical Methods final course grade as a dependent variable, revealed a weak positive relationship with all of the independent variables—albeit several coefficients are above 0.200.

Finally, because there is a positive relationship between a student's final grade in the course and self-efficacy level, it is possible that the students' subtopic Gauss Elimination score on the EOQs and their grades in their Calculus 3 and ODE courses contribute more than other characteristics/traits to how well they achieve in the course.

- With the **learning preferences**, all relationships were very weak relationship with SLE Score and Numerical Methods final course grade. This finding suggests that students' ability to achieve in the course is not necessarily attributed to their learning pattern preferences. This may be explained because the measure for learning patterns allows students to use the appropriate pattern for a given problem-solving process. However, this does indicate that regardless of the chosen pattern, the success of the student is more likely attributed to some other experience, characteristic, or trait.
- The regression model for **pre-requisite courses** revealed that there was a moderate negative relationship between Calculus 3 and the SLE score with -0.436 and a significance of 0.014. This can be inferred that this relationship did not occur by chance with 95% confidence.
- Finally, a regression model of **self-efficacy** revealed that only 14% of the SLE score could be explained by the relationship of the self-efficacy variables. This can be inferred because of the 0.059 significance of the regression ANOVA. More specifically, there was an inverse relationship between the self-efficacy score (-0.177) and the SLE score (see Appendix A on Self-Efficacy).

Overall, these findings reveal that the null hypotheses for the effects that number of attempts with the EOQs, time duration on the EOQs, learning preferences, and self-efficacy be accepted with special consideration for pre-requisite grades.

H<sub>1</sub>: Student learning styles have no effect on SLE score  
*Accept*

H<sub>2</sub>: Student self-efficacy has no effect on SLE score  
*Accept*

H<sub>3</sub>: Student grades in prerequisite courses have no affect on academic achievement  
*Accept with reservation*

Given that the EOQs online environment is to help all students improve in demonstrating an understanding of simultaneous linear equations, it can be inferred that regardless of a students' learning preference and pre-requisite grades will have little to no effect on their ability to demonstrate knowledge of SLE. However, the students self-efficacy and their work with subtopics of Gaussian Elimination and LU Decomposition can have an effect on how well they demonstrate knowledge of SLE and perform overall in the Numerical Methods course with a grade of B or higher.

### Focus Group Results

For the focus group conversation, students responded to seven (7) questions regarding their experience with the EOQ online practice tool. Overall, the students indicated that they really enjoyed working with EOQs for several reasons. First, there was no time limit so there was no stress or pressure to complete the problems. This allowed the students to stop and take a break or think through what they needed to do to complete the problem. Second, the students indicated that EOQs were helpful in preparing for their exam and in-class quizzes, allowed them to study more than they would have without EOQ, and enjoyed getting the immediate feedback to help with “the little things”.

With regard to ease, the students indicated that on a scale of 1 – 5 (with one meaning easy and five meaning very difficult), EOQs rated at 1 or 2. The students indicated that working with EOQs was easy because you could “fill in the blank with the answer instead of working step-by-step.” This observation may be because students maybe getting some their answers from a Java applet on the internet or writing a short MATLAB program. This was discouraged by requiring each student to submit the first quiz attempt also by hand, and one problem was then randomly selected from the handwritten submission and graded. The total grade for a quiz was then assigned based on equal weightage given to the highest score recorded online and the grade scored on the handwritten submission. This is the reason that the time on task for second attempt and later, and the number of attempts have not been included in the study.

Also, being on Blackboard made access easy since the students use Blackboard every day. When asked about anything that was difficult about EOQs, the students said, “It wasn’t difficult at all.”

Students also responded to a set of questions that asked how (or if) EOQs had helped them with understanding their coursework. The students indicated that the questions in EOQs helped them identify what you knew and what you did not know. In addition, you could use EOQs for homework/practice, which was better because with homework you are not always sure if your answers are correct, and with EOQs, you know when your answers are not correct.

One area of improvement the students suggested was that they did not like to start the quiz over if they got something wrong during the quiz. The students wanted the option to “begin where you went wrong”, instead of having to start over. In addition, the students indicated that they would like hints to be included in EOQs when they clearly demonstrate difficulty at a given point in the quiz. Also, they would like to see procedures to help them prepare and provide quizzes that had more of the information that would be included on their tests.

Ultimately, the students would recommend EOQs to other students at USF as well as other universities. The students all agreed that the tool was a good evaluation of “your understanding and knowledge of the subject”.

### Student Performance Comparison

Student performance was evaluated by the number of correct answers in the Simultaneous Linear Equations portion of the multiple-choice final examination (total of 4 questions out of a 32-question test). In 2009, homework was assigned from the book but not selected for grade, while in 2010, we assigned and graded (3% of overall grade) the online quizzes for the topic of Simultaneous Linear Equations. One tailed t-test comparing the performance of students in the 2009 spring/summer terms ( $N=109$ ,  $\mu=2.72$ ,  $\sigma^2=0.87$ ) with those in the 2010 spring/summer terms ( $N=134$ ,  $\mu=2.89$ ,  $\sigma^2=0.88$ ) showed a significant improvement;  $t(232)=1.428$  and  $p=0.08$ .

### **SUMMARY**

In summary, the results of the EOQs at USF during the spring 2010 and summer 2010 semesters revealed that overall students' learning styles, efficacy, pre-requisite grades (with the possible exception of Calculus 3) with EOQs did not have a significant relationship to the students SLE scores. This is possibly a positive outcome of the EOQ environment because regardless of the students pre-course disposition, they can be successful with demonstrating knowledge of SLE if they have unlimited access and time with EOQs.

With regard to their profile, the majority of the students had a high preference for the sequential and precise learning patterns in spring 2010, while the majority had a high preference for sequential, precise, and technical in summer 2010. Results of the students self reported, self-efficacy profile revealed that students tended to have a medium to high efficacy in learning new concepts with technology or with hands on experience, but reported a medium to low self-efficacy when discussing topics with which they were unfamiliar.

With regard to the focus group, the students overwhelmingly indicated that the EOQs practice tool was easy to use, helpful to increasing their understanding of the course work, improved their ability to perform well on tests and in-class quizzes, and allowed them to practice problems and concepts without the stress and pressure of being timed. Ultimately, the students would recommend EOQs to other students as well as other universities as long as some of the suggestions for improvement were implemented.

The final examination performance of students in the semesters when EOQs were used showed significant improvement over the semesters when homework was assigned but not graded.

### **ACKNOWLEDGEMENTS**

This material is based upon work supported by the National Science Foundation under Grant Nos 0717624, 0836981, 0836916, and the Research for Undergraduates Program in the USF College of Engineering. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors would like to thank Dr. Patricia Maher of the USF Tutoring and Learning Services in conducting the Learning Pattern survey.

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## Appendix A

### Selected Self-Efficacy Statements and Percentage of Students Rating 5 or Above

*(Students were asked, “How well can you . . .” do the following on a scale of 1 to 7 with 7 meaning very well on my own.)*

<b>Statement</b>	<b>Spring 2010</b>	<b>Summer 2010</b>
Learn new concepts using technology based applications or software.	64.2%	76.5%
Remember new information presented in class	42.9%	56.0%
Remember new information presented in textbooks	26.2%	42.7%
Remember new information from hands-on experience	76.2%	91.2%
Arrange a place to study without distractions	66.6%	72.1%
Motivate yourself to do work that is difficult for you to understand.	50.0%	50.0%
Participate in class discussions when you are unsure about the topic.	17.7%	29.4%