Expanding Flipped Classroom Options to Accommodate Different Learning Styles

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Abstract
In a flipped classroom pedagogy, students are expected to complete pre-work prior to attending lecture in order to prepare for lecture. Typically, pre-work is in the form of reading material or watching videos. This paper describes an alternative option for a first year MATLAB programming course that allows students to work directly with the software in order to learn basic concepts and prepare for more in-depth activities in lecture. It was designed to appeal to students that prefer a hands-on learning style.

Introduction
In the fall semester of 2012, the College of Engineering and Applied Science at the University of Cincinnati began offering a two semester sequence, Engineering Models I and II, which was required for all incoming first-year students. The courses introduce MATLAB as a programming and computational tool with an emphasis on problem solving, data analysis, and engineering applications. At the end of the first year, students indicated in the course survey that they didn't feel as if they got enough practice with MATLAB in lecture and were therefore not able to complete labs during the recitation period. Also, some instructors simply read from PowerPoint slides and didn't demonstrate any concepts using the software. Even the instructors that did use MATLAB during lecture didn't have much time since lectures meet only once per week for 55 minutes.

The second year, 2013-2014, a flipped classroom approach was introduced.[1] Videos were created to introduce various programming concepts. Students were expected to watch the videos prior to attending lecture and were given a short multiple choice quiz at the beginning of lecture on the video material. Students brought their laptops to lecture and lecture time was spent writing scripts and demonstrating MATLAB functions. Student performance on exams improved and many more students were able to complete recitation assignments during the two hour lab period each week. 70% of the students indicated that they always or often watched the videos. Students that didn't watch the videos indicated they were long and/or boring and it was much faster to read the accompanying PowerPoint slides rather than listening to an explanation. The only change made in 2014-2015, was to shorten the videos by cutting some extraneous material and breaking longer videos into shorter ones.[2] A table of contents was added to make the videos easier to navigate. The number of students indicating that they always or often

watched the videos increased to 81%, but some students indicated in the course survey that listening to audio explanations was not at all helpful to them.

Engineering Models Practice System
This past year, an alternative to the videos was offered to students called the Engineering Models Practice System (EMPS). The practice system is a MATLAB application GUI and is set up very similar to the software courses offered by Codeacademy.[3] It is designed to appeal to students that learn by doing rather than by listening. Students first read background information on a topic, look at sample code and try to predict results. Next, they are given a series of programming tasks to complete to test their comprehension.

In order to introduce students to the EMPS, all students downloaded and installed the EMPS during the first recitation section. Students completed a very simple 3-step exercise on naming variables and math operations so they would understand how to launch the app, how to load a data (.mat) file, how to navigate through the topics, and how to take the quiz at the end.

Each week for the rest of the semester, pre-work for lecture was posted on Blackboard. The pre-work folder typically had two options: watching video(s) or using the EMPS. During the course of the semester, there were a couple of topics, curve fitting and debugging, which only had a video option because they simply didn't work well within the context of the EMPS.

Figure 1 shows what the EMPS looks like when students launch the app. The first thing a student must do is click on the Load Lecture File button and browse for the data (.mat) file available for download from the Blackboard site. If students find an issue with the EMPS, they can click the Report a Problem button and send an e-mail.

The pushbutton on the top left is for instructors. The content for each lecture file is generated from a text file. Instructors create the content in the text file and use the EMPS to convert that text file into a data file, which can easily be uploaded and downloaded from Blackboard. Information on creating text files and generating a date file from the text file and any other added files such as images is provided.
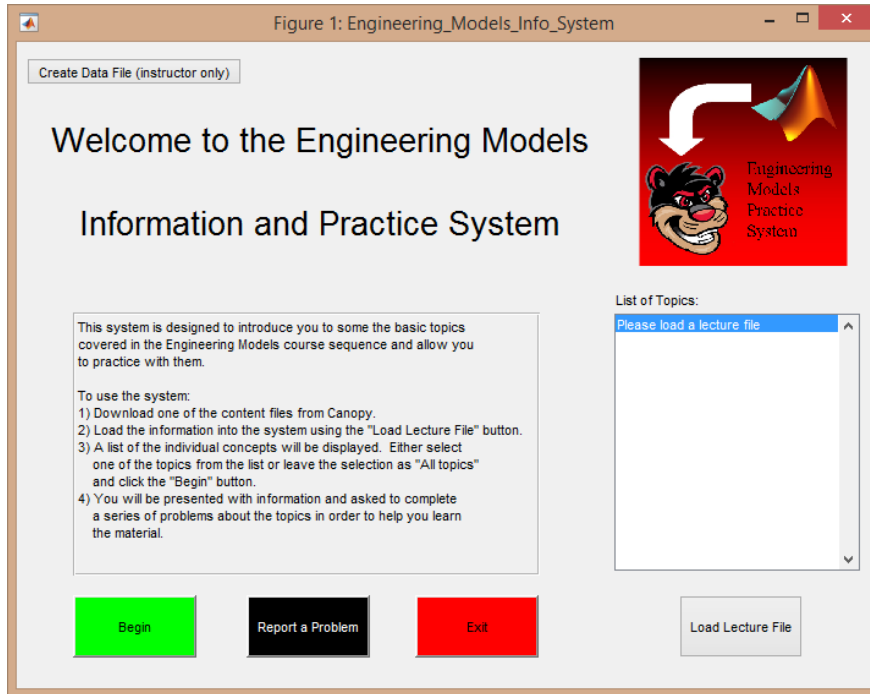
Figure 1: Engineering Models Practice System when Launched

One of the first topics covered in Engineering Models I is graphing. Figure 2 shows what Students see when they load the Graphing Lecture File. Students can click on a particular topic or exercise or simply push the Begin button to go through all of the topics.
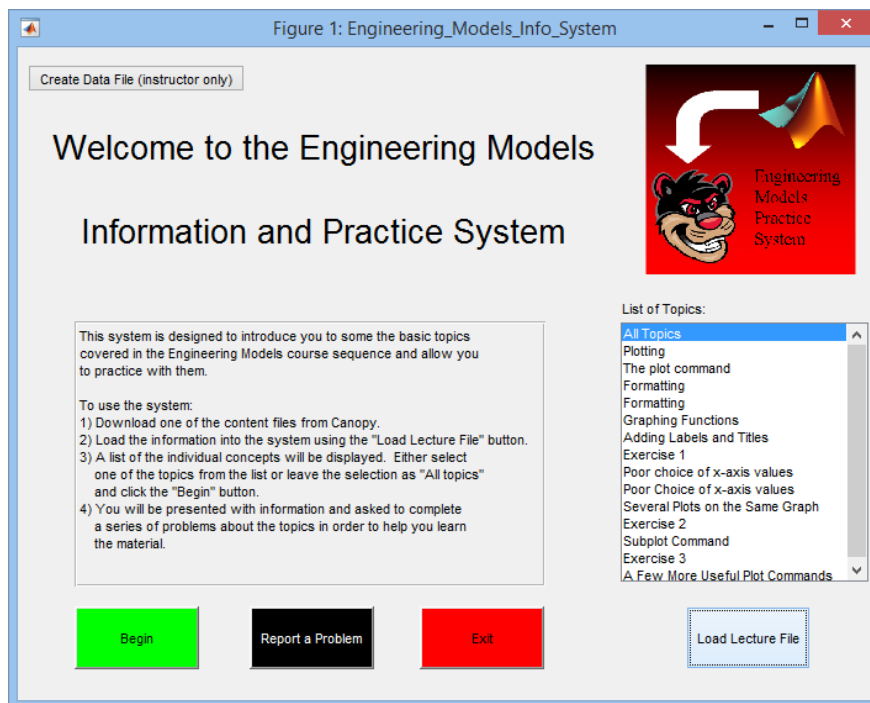

Figure 2: Engineering Models Practice System with Data File Loaded

Figure 3 shows one of the listed topics: Graphing Functions. The text box on the left provides background information on the topic for students to read. There is also a text box labeled Task. In this case the students are simply asked to look at the code and see if they think they understand what will happen. Once they feel they understand the code, students simply click the Check Answer button to see the results – in this case a plot of a polynomial. Numerical results would appear in the Result text box.
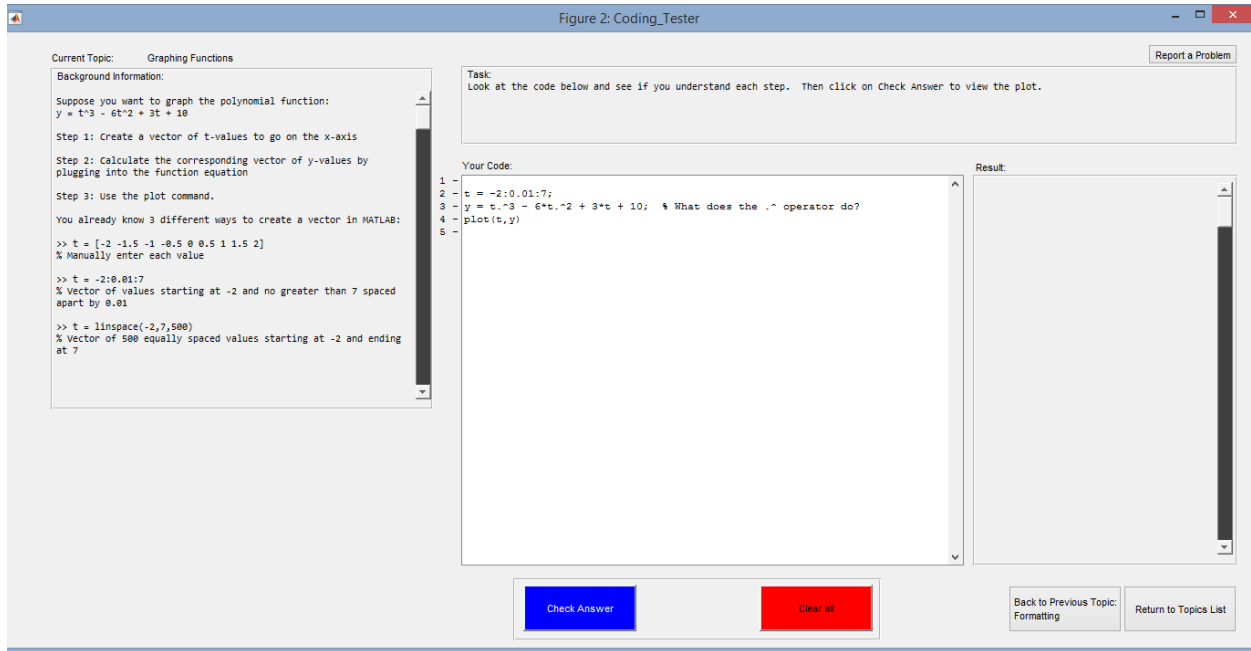

Figure 3: A Topic – Graphing Functions

Figure 4 shows one of the hands-on exercises for the graphing pre-work. Some code is provided but students are expected to add code to plot a simple polynomial. They are also asked to add a label to the x-axis. Adding labels and titles is on the list of topics and was covered prior to this exercise.
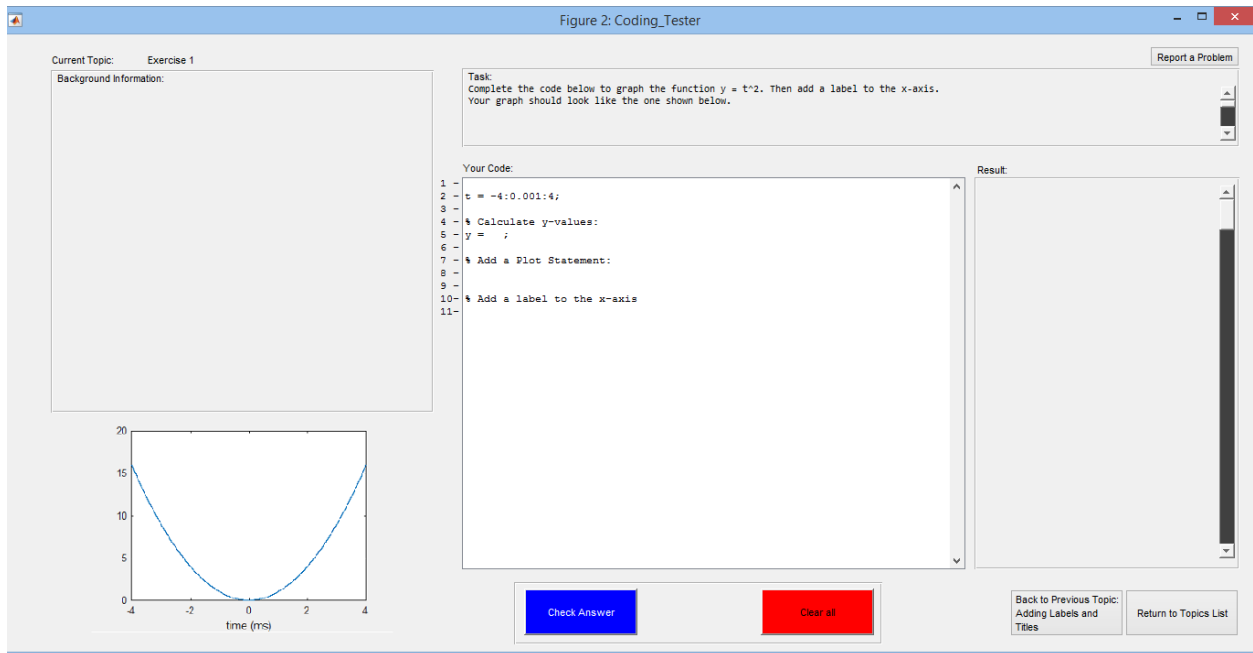
Figure 4: Exercise 1 – Graph a Function

Figure 5 shows what happens if students make the classic error of using y = t^2 rather than the entry by entry operator y = t.^2. The same error message that would appear in the MATLAB command window shows up in the Result text box. If students leave out some required element such as the xlabel for this example, they get a message in the Result text box stating that all of the required elements were not included in their code.
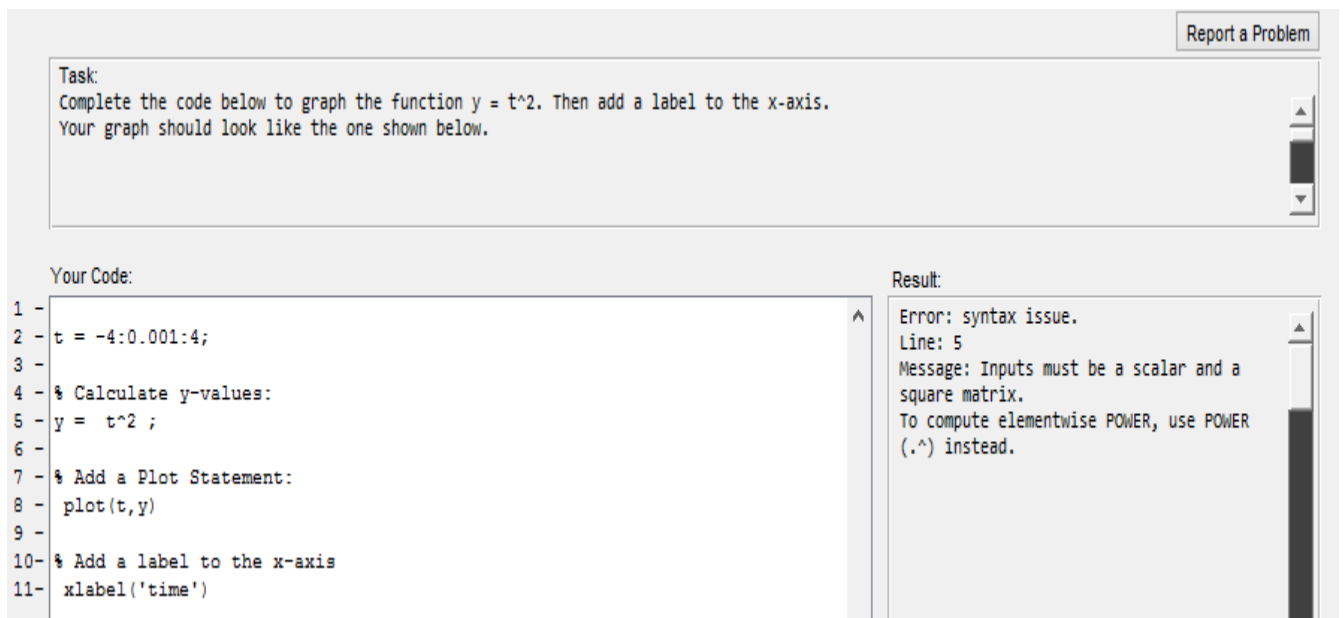

Figure 5: Displaying Errors or Output

After completing all of the topics, students are given the option to take a quiz to test their comprehension. This quiz is identical to the quiz at the end of the videos and does not count toward a student's grade; however, a very similar quiz is given at the start of lecture which does count. Figure 6 shows a couple of screen shots for the quiz. The quiz consists of multiple choice questions and when a student completes the quiz, he or she is given feedback on each question. The student then has the option to re-take the entire quiz, re-try the questions that were answered incorrectly, or exit out.
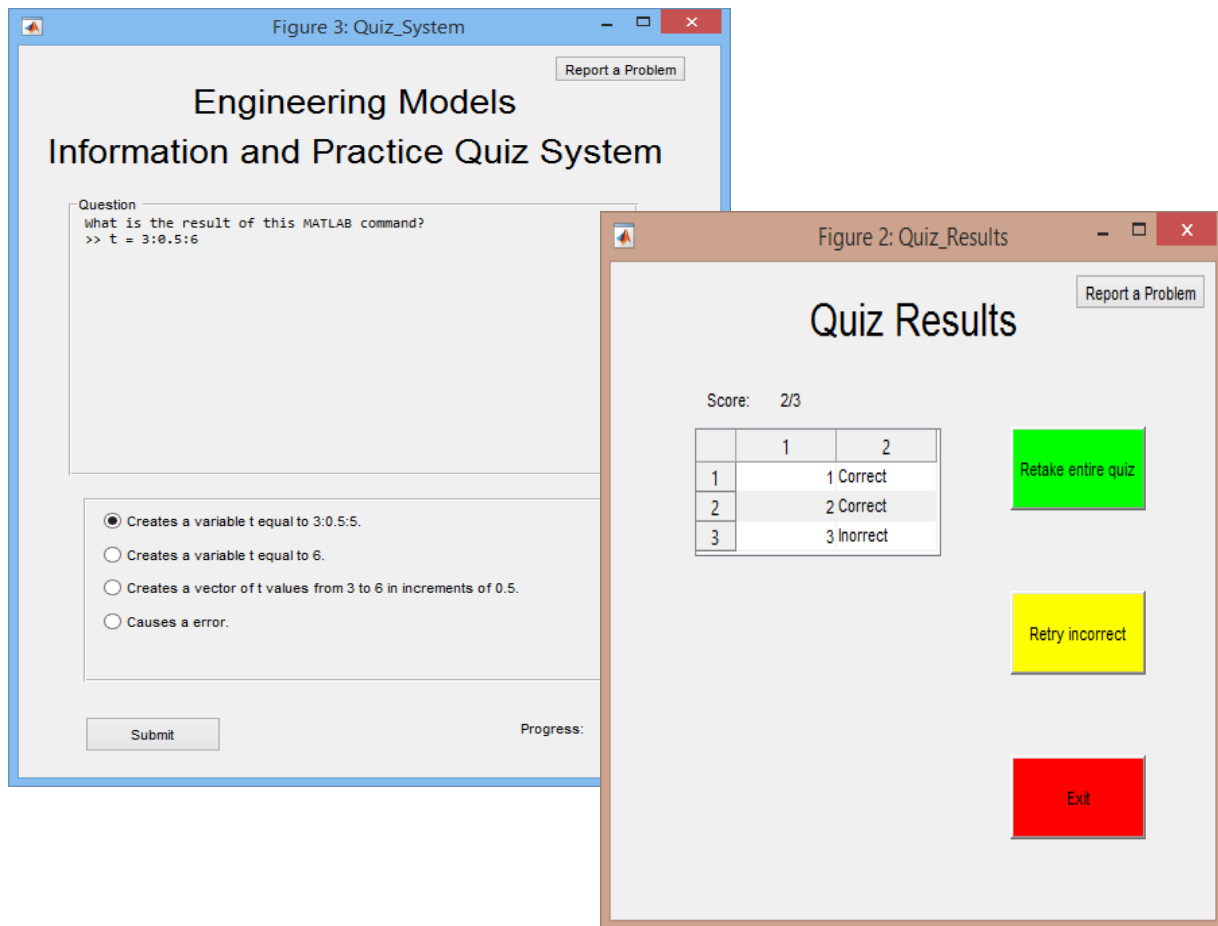

Figure 6: Testing Understanding

Comparison to Videos
The EMPS requires students to read background information and look at MATLAB code to try to predict the output of that code. In addition, students are given tasks to write and then test code of their own. In the videos, students listen and observe as background information is presented and code is demonstrated. At the end of the video is a "Your Turn" section that has a series commands for students to type at the MATLAB command prompt and observe results. Students aren't given any tasks that involve writing their own code although they could certainly experiment with the provided MATLAB commands if desired. As previously mentioned, both the videos and the EMPS have the same practice quiz at the end to test comprehension of the topics.

6

Student Survey Results

1040 out of 1232 students enrolled in the class during the Fall 2015 semester (84.4%) completed an end of course survey for Engineering Models I. The survey had questions specific to the videos and the EMPS. Students were asked to rank which pre-work option helped them the most (Videos, EMPS, Reference Slides, Practice Quizzes). They were also asked how often they viewed the videos or used the EMPS and were given the opportunity to make comments as well.

In 2014, 81% of the students always or often watched the videos with the other 19% either relying on reference slides, taking practice quizzes, or simply coming to lecture unprepared. In 2015, 65% of students always or often watched the videos, 16% of students always or often used the EMPS, and the remaining 19% again used reference slides, quizzes, or came unprepared.

Figure 7 shows student choices for best pre-work option overall and also broken out by gender and prior programming experience. Videos were the dominant first choice for all of the students regardless of gender or prior programming experience. The biggest users of the EMPS were students with prior programming experience followed by female students.
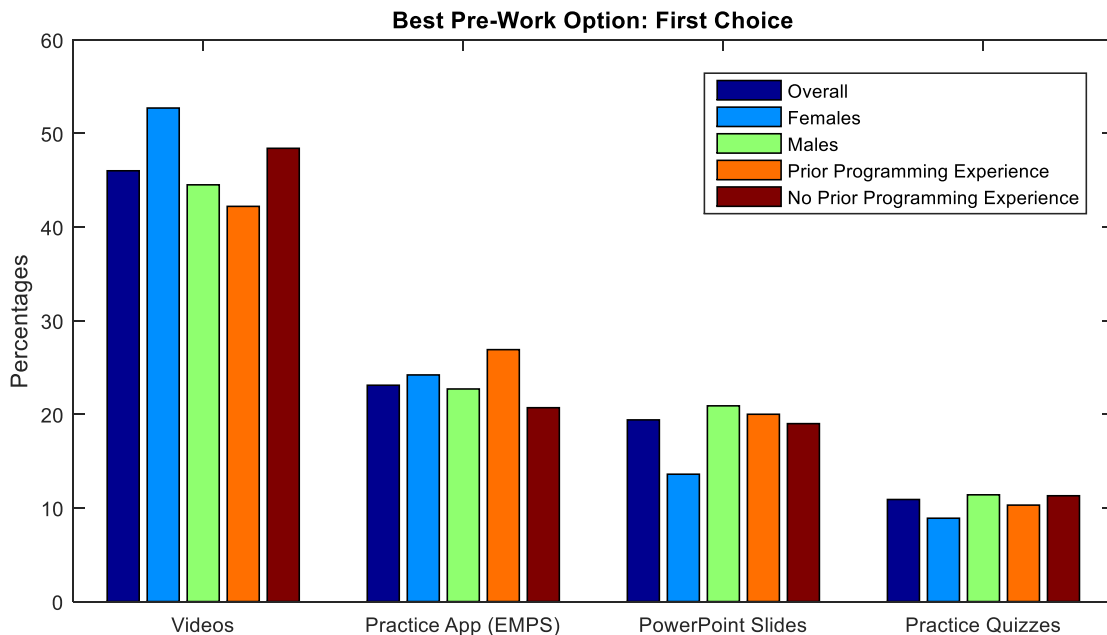

Figure 7: First Choice for Best Pre-Work Option

Students were also asked to comment on the EMPS and many students appreciated the opportunity for self-paced and hands on learning as seen from this sample of student comments:

- *I liked the hands on application of the lessons in the practice app, they prepared me much better than the videos.*
- *It walked you through the information while providing examples and practice problems. I feel that I learned more when I had the opportunity to work through the problems instead of listening to them being explained*

7

- *I really liked the app because you could go at your own speed, while the videos could be very lengthy sometimes. The only downfall to the practice app was that if there was a problem that I didn't know how to do and it wasn't in the power point then I couldn't continue with the app. I didn't like this because it didn't allow me to see what I was supposed to do to answer the question or problem.*

Included in the student comments were a couple of suggestions for improving the EMPS:

- Make it easier to navigate back and forth between topics in case students want to go back and review previous code or re-read some of the background information
- Offer hints and/or solutions in case a student gets stuck on one of the tasks and cannot move on.

Conclusions and Further Work

Although more students chose to watch the videos, there was still a sizable number of students (16%) that used the Engineering Models Practice System to prepare for lecture. Currently the EMPS is being revised to make it easier to navigate back and forth between topics. Hint and Solution buttons will also be added so students don't get frustrated if they get stuck on a particular task.

The survey indicated that 19% of the students continue to use the reference PowerPoint slides or the practice quizzes or do nothing at all to prepare for lecture. Although the PowerPoint slides work very well for students that have programming experience and simply want to learn the MATLAB syntax, they don't work well for students that are new to programming. We hope to see more students viewing the videos or using the EMPS system next year. The improvements being made to the app should make it a more attractive option.

Bibliography

1. Ossman, K. and Bucks, G., "Effect of Flipping the Classroom on Student Performance in First-Year Engineering Courses", Proceedings of the ASEE Conference, Indianapolis, IN. (2014).
2. Bucks, G. and Ossman, K., "Variations on Flipping a First-Year Engineering Computing Course," Proceedings of the ASEE Conference, Seattle, WA. (2015).
3. http://www.codecademy.com/learn