Work-in-Progress: Flipped Classroom Approach for First Year Engineering Students

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Abstract – **Flipped classroom models are becoming increasing popular in engineering education as these models move away from the traditional lecture format and to a more student-centered model where students can work and receive feedback during class time. A flipped classroom model has been applied to a first year engineering programming course at the University of Tennessee in Knoxville. The purpose of the work-in-progress study was to investigate the impact of the flipped classroom model on student performance in the course.**

Index Terms – flipped classroom, student performance, programming course,

INTRODUCTION

The flipped classroom is an educational concept that is growing in popularity, where the traditional class-lecture and home-work are inverted to home-lecture and class-work. Engaging video lectures are viewed by the students before the class period, while the class time becomes a workshop dedicated to practical exercises and discussion. The flipped classroom model provides a space where students can apply the acquired knowledge and clarify lecture content under the direct supervision of the instructor, resulting in increased student achievement [1] and higher student engagement in the lecture topics [2]. While the video lecture is a key component of the flipped classroom, it is not the video itself, but how it is included in the overall flipped classroom model that plays a significant role in the success of this approach. In this work in progress article, we begin with a description of our approach to the flipped classroom; approach that goes beyond the use of video lectures to provide an engaging online home-learning environment for first year engineering students. This work in progress article ends with a discussion of the preliminary results of a pilot study that is being conducted to investigate the impact of our flipped classroom model on student performance in the course. Performance data includes grades for module quizzes and common course exams compared between control semesters (traditional classroom) and the pilot study semester.

LITERATURE REVIEW

The use of flipped, or inverted, classrooms has become a popular topic in engineering education over the past several years. At the 2014 ASEE Conference, two special sessions and eleven technical sessions were held to cover topics regarding the flipped or inverted classroom, a dramatic increase from the previous conference year. A flipped classroom is typically defined in the following manner: "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa."[3] What we learn from this definition is that intent of flipped classrooms is to move more student-centered approaches into the classroom, while teacher-centered activities, such as lecture and general knowledge distribution, can be focused outside of the classroom. The move to student-centered pedagogy is largely based on the pivotal works of Piaget[4] and Vygotsky[5], who theorized that cooperative and collaborative work were fundamental in the knowledge building process. While this is a widely accepted definition of the flipped classroom, Bishop and Verleger[6] found that in the literature there is a varied range of activities that educators and researchers are classifying as 'flipped.' For the purposes of our work, we use the definition presented by Bishop and Verleger: "interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom" [6].

While literature on the development of pedagogy is helpful, it is also important to understand the impact of such a pedagogical shift from the traditional classroom model. In their literature survey, Bishop and Verleger [6] also found that much of the current work in flipped classrooms has predominantly focused on developing the pedagogical intervention, while little work has focused on understanding the impact of flipped classrooms on student learning outcomes or performance in the classroom. Through this survey, only two studies representing the strict definition of the flipped classroom (as presented earlier) while focusing on the impact of the pedagogy on student outcomes were found. Though both studies showed modest improvements in student performance, these studies alone cannot be relied upon to prove the efficacy of this pedagogical model in the engineering classroom. Therefore, continued research in this area is still required. Consequently, the overall purpose of this work in progress study is to investigate the impact of

shifting to a flipped classroom approach on student performance in a first-year engineering programming course. Here, preliminary results of student performance are presented.

UTK FLIPPED CLASSROOM APPROACH

The flipped classroom model is being utilized to teach the second half of a first year computer programming class of the engineering fundamentals program at the University of Tennessee. This class targets approximately 700 students between fall and spring semesters and is a requisite for all engineering majors. Specifically, the second half of this course focuses on teaching MATLAB via flipped classroom, while the first half is mainly dedicated to advanced Excel via traditional classroom instruction. The fundamental concept for our flipped classroom approach is the following: it is not the video lecture itself, but how it is included in the overall flipped classroom method what plays a significant role in the student learning process. Therefore, we approached the self-paced *home-lecture* portion with concise, well-organized material containing illustrative examples and as much graphic content as possible to enhance student's comprehension and retention; while in the *class practice* portion we intentionally attempted to reinforce the lecture's fundamental concepts via exercises that would gradually immerse the students in more complex scenarios.
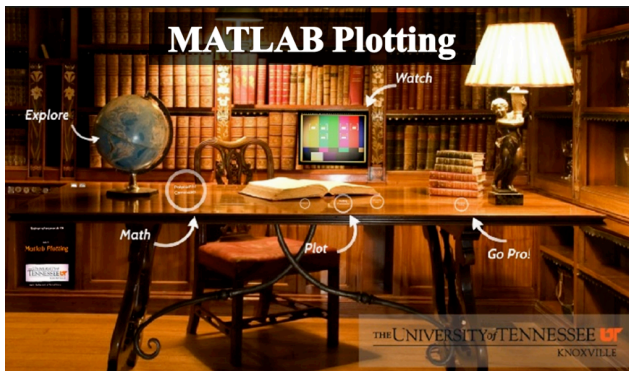

FIGURE 1
ILLUSTRATION OF SELF-PACED HOME-LECTURE FOR THE MATLAB PLOTTING MODULE

Fig. 1 illustrates our self-paced home-lecture approach for the MATLAB plotting module. Similar to all our flipped lectures, it is a collection of short videos immersed in a Prezi framework; the lecture is delivered through the course website and can be streamed from computers, tables, and smartphones. To ensure participation, short quizzes pop-out as the students' progress through the lecture; the quizzes must be answered correctly before they can proceed to the next topic. The in-class practice session is also web-based and has been designed to gradually immerse the student in the application of the concepts learned in the lecture, creating a hands-on workshop environment. The order of the class-work is the following: first the "Examples", where

application problems are solved step by step; second the "Practice", where students work on increasingly challenging problems, knowing only the final answer; and finally the "Quizzes", where students solve problems, and those problems are graded.

METHODS

Based on the theories associated with flipped classroom pedagogy, we began this study with the hypothesis that students participating in a flipped classroom for programming would perform better on quizzes and a final exam than those students who participated in the traditional lecture format.

Participants
Participants of this study include students enrolled in the first-year programming course at the University of Tennessee in Knoxville. Participants were divided into two sub-groups: control and flipped. The participants in the 'control' group participated in spring year 1 and did not participate in the flipped lectures for the MATLAB portion of the course. The participants in the 'flipped' group participated in spring year 2 and did participate in the flipped lectures for the MATLAB portion of the course. The control group consisted of 152 participants and the flipped group consisted of 146 participants.

Data Collected
The data collected for this study included lab participation grades, lab quiz grades, final exam grades for the MATLAB portion of the course, and final class grades for the class. The data used for analysis includes: a) 5 lab participation grades, b) 9 lab quiz grades, c) 1 final exam grade, and d) 1 final course grade. The data was originally collected as assessment only data but IRB was later approved to use the assessment data for research purposes. Therefore, the results of this study are presented in aggregate to protect the identity of participants.

RESULTS

The analysis of the pilot data focuses on investigating differences in the two samples: control and flipped. Therefore, an independent sample t-test was used to determine if there was a difference between the two samples. Statistical significance was determined with a 95% confidence interval ($p > 0.05$). The results of the analysis of the pilot data from this study are shown in Table 1.

From the analysis, we can see that there was a statistically significant drop in performance between the two groups in average lab quiz score, exam practice score, and final course grade, with the flipped group performing at a lower level than the control group. There is no statistically significant difference in average lab participation score or final exam score between the two groups, though on average, the flipped group performed four points lower on the final exam than the control group.

Table 1
Quantitative Analysis of Control and Flipped Samples

		N	Mean	Std. Deviation	t	Sig. (2-tailed)
Avg Lab Part. Score	C	152	91.01	18.39	.79	.428
	F	146	89.27	19.45		
Avg Lab Quiz Score	C	152	91.02	11.71	3.23	0.001**
	F	146	86.15	14.30		
Exam Practice Score	C	152	93.55	16.65	2.43	0.016**
	F	146	87.39	26.34		
Final Exam Score	C	152	80.03	17.77	1.76	.080
	F	146	76.03	21.50		
Final Course Grade	C	152	87.91	9.08	3.19	0.002**
	F	146	83.88	12.49		

DISCUSSION

We started this study with a hypothesis that engaging students in a flipped classroom model for computer programming would lead to a positive difference in exam performance. The analysis for this pilot study does not support this hypothesis. In fact, for the initial pilot study, it seems as if our flipped classroom had the opposite effect than we had hoped it would at the beginning of the semester. Now we ask the question: why did we see a drop in performance between the control and the flipped groups? While we do not have formal data to answer this question, our research team would like to propose a few areas for future investigation that we plan to pursue.

Student Motivation
Data for the pilot study was collected during two subsequent spring semesters for EF 105. Students that take EF 105 in the spring semester typically enter the university in the fall but are not calculus ready and thus cannot start their Engineering Fundamentals sequence until they have successfully completed a pre-calculus course. This lack of preparation could potentially be linked to issues of academic motivation. According to Bandura the intensity and the effort spent in a situation highly depends on the person's confidence about success, becoming the fundamental motivation for accomplishment [7]. Feelings of low self-efficacy may impact students' performance, especially in flipped classroom courses where the students' unsupervised self-work plays such important role in learning process. Furthermore, we observed that many students of the flipped group did not even try to complete the exam practice, which may explain the drop in performance for the exam practice and the final exam score. The research team would like to further study the motivational profiles of future EF 105 students in order to determine if motivation plays a role in their participation and performance in the course.

Student Preparation for Course
As the data for the pilot came from spring semesters, there also may be an effect due to uneven student preparation for the course. In fact, we observed that the performance of the flipped group was also inferior during the first-half of the semester, where traditional classroom pedagogy was used. The literature suggests that the self-regulation learning process of underprepared students that take "remedial" courses is quite different from the one experienced by traditionally admitted college students [8]. Therefore, it will be interesting to see potential differences in performance when comparing a control and flipped group for students in the fall semester. We plan to implement the flipped classroom model into this fall's cohort of students and collect similar data in order to determine if there is an impact on performance.

Full Course Implementation
The flipped classroom model was only implemented for a portion of the EF 105 course. As was suggested by Herried and Schiller [9], we realize that students tend to put up resistance to changes in how they are used to participation in the classroom. Moving to a flipped classroom model is a big change for many students, especially first year ones. Therefore, we realize that the limited time frame of our intervention may influence the study outcomes. Our future work intends to expand the flipped lectures throughout EF 105 in order to investigate its impact through a whole semester.

Student Learning
While grades are one useful objective measure for looking at student performance, we also realize that a more appropriate way of looking at learning in flipped classrooms is to investigate the impact of the model on specific learning objectives. Grading scales and assessment difficulty can fluctuate from year to year. For example, lab quizzes for the flipped group were somewhat more difficult than the lab quizzes for the control group, making the differences between the two groups difficult to interpret. . In future work, we plan to investigate student performance and learning through defined learning objectives and assessment methods in order to more accurately understand the impact of our shift to the flipped classroom.

CONCLUSIONS

In an effort to move towards a more student-centered pedagogy for a first year programming course, we implemented a flipped classroom for a portion of our first year computer programming class. Though the initial pilot data did not show the positive trends we hoped to see, our research team has identified several areas for further investigation in order to better understand the impact of the flipped classroom on first year student performance and learning.

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