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A Novel Peer-Assisted Hybrid Flipped Classroom Model Using Online Discussion

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Abstract

In this paper, a novel flipped classroom model using a hybrid approach combining traditional, flipped, and an online discussion for peer-assisted learning is presented. In this model, a specifically designed set of lecture notes were prepared by the faculty teaching the course to use in conjunction with online videos to supplement the students' learning process. To initiate discussions, students were asked to post their questions on an online discussion to trigger interactions among themselves and the faculty outside the classroom. Based on the outcome of these discussions, a 15-minute review lecture was prepared by the faculty to address the issues that were raised during the student groups' discussions. Following this brief lecture, the class was turned into a studio environment in which students were able to put into practice what they have learned inside and outside the classroom. Before the end of the lecture session, an online quiz was administered to monitor the students' level of preparation and understanding of the topics being covered. It was shown that the proposed model had succeeded in 1) establishing a virtual peer-assisted learning environment outside-the-classroom, 2) covering more topics by increasing the pace of learning, 3) improving the quality and complexity of the questions being addressed, 4) providing a conducive platform to exchange creative ideas, and finally, 5) increasing the students' overall performance and success in the course. To validate these findings, a quantitative and qualitative analyses were conducted using statistical assessment methods. The effectiveness of this model was verified by assessing the students' performance in pre- and post-exams. Assessment results indicated that students subject to this study were able to score significantly higher on post-exams than what they were previously able to achieve. This demonstrated the improvement in the students' performance level. Furthermore, all the instructional tools that were developed and implemented in this hybrid classroom environment were also presented and discussed in this paper.

Introduction

Recent studies have called for major pedagogical reforms to improve the quality of engineering education by incorporating more active teaching styles¹. Modern teaching styles apply student-centered learning techniques to effectively improve the quality of the learning process^{2,3}. However, in today's tightly packed engineering curriculum, the amount of lecture time that faculty can afford to allocate to such active learning activities is very limited. In the early 2000's, the notion of flipping the classroom started to sound as a viable solution for such a problem^{4,5,6}. The effectiveness of active learning pedagogy and the huge technological advancements in the area of educational technology were the key factors that made classroom flipping possible⁷. Flipping a classroom has the effect of altering the dynamics of the learning process by switching the role of the student from a passive to an active role. Under this model, the student is given instructions to watch a set of short online videos about a specific topic usually outside the classroom. In this model, the role of the instructor has switched from being a leader to a facilitator. Therefore, classroom flipping has the advantage of extending the learning process beyond the classroom walls and allowing students to learn at their own pace. Consequently, this frees up lecture time and allows for more active learning activities to take place such as

interactive discussion, collaboration, and problem solving thus keeping the students constantly engaged in the learning process.

Flipping the classroom by substituting traditional lecturing with watching online videos has shown to be an efficient mean of student learning⁸. However, this has the adverse effect of eliminating the adaptive learning environment that the faculty has relied on to tailor their lectures in the traditional classroom settings^{7,9}. To the best of our knowledge this effect has not been addressed in the flipped classroom literature. In this paper, a novel approach to create a virtual peer-assisted learning “outside-the-classroom” environment is presented. To achieve this goal, a hybrid model combining online videos and lecture notes tailored to fit various students’ learning styles was developed to incorporate the interactive learning dimension into the flipped classroom model.

Peer-Assisted Hybrid Flipped Classroom Model

This model was developed based on utilizing an online discussion component through the course management software allowing students to virtually interact outside the classroom. The advantage of such approach is to create a peer-assisted learning environment that did not exist in other flipped classroom models presented in the literature. In this model, a detailed set of lecture notes are prepared by the faculty teaching the course based on students’ feedback using the online discussions.

These lecture notes are designed to supplement the online video for students who favor the verbal learning style. The content list of the lectures notes for a Computational Thinking course introducing Matlab for engineers is provided in Figure 1.

Lectures

Lecture 1 - Engineering Essentials	1
Lecture 2 - Engineering Ethics	5
Lecture 3 - Engineering Communications	9
Lecture 4 - Introduction to Problem-Solving	15
Lecture 5 - Introduction to Matlab Environment	19
Lecture 6 - Matlab Basics (Arrays & Variables)	27
Lecture 7 - Array Operations and Built-in Functions	33
Lecture 8 - Introduction to Plotting and Debugging	41
Lecture 9 - Logical Data Types	49
Lecture 10 - Conditional Statements	55
Lecture 11 - More on Plotting in Matlab	63
Lecture 12 - Structured Programming	71
Lecture 13 - Data Modeling using Linear Regression	77
Lecture 14 - Introduction to Matlab Functions	83
Lecture 15 - Other types of Matlab Functions	87
Lecture 16 - Numerical Techniques (Random Number Generation)	91
Lecture 17 - Cell Arrays	97
Lecture 18 - Structure Arrays	103
Lecture 19 - Structure Array Examples	107
Lecture 20 - Input/Output Functions	111
Lecture 21 - Image Processing	115

Figure 1- Computational Thinking course lecture notes

For the “outside-the-classroom” component, MATLAB Marina^{10,11,12} online video lectures were used in this Computational Thinking course as illustrated in Figure 2.

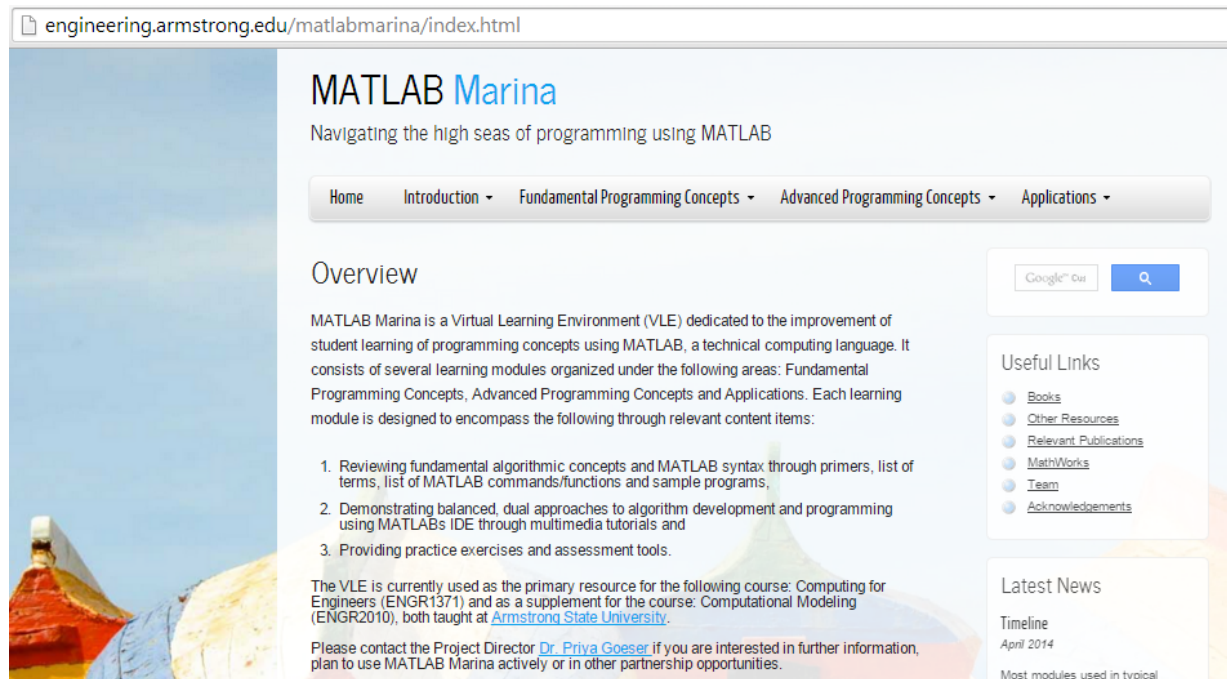


Figure 2- MATLAB Marina Webpage

As part of this model, students were also instructed to post their questions online in a discussion group with the purpose of initiating 2-way communication hub for students and faculty to exchange ideas and ask and answer questions in an informal setting. Participation in this activity was required and students were assigned participation grades based on each their activity. These online discussions were necessary to help the faculty prepare a 15-minute lecture review which is an integral part of this hybrid model. The lecture review was incorporated to provide interactive discussion between students and faculty inside the classroom. After the lecture review, the class was turned into a studio where students put into practice what they have learned and reinforced through hands-on activities. An online quiz was administered towards the end of the lecture to monitor the students' level of preparation and understanding of the topics being covered as a mean of formative assessment. In addition, a formative feedback was implemented in the form of bi-weekly anonymous Google Form survey to help faculty adapt the model to fit the students' needs^{13,14}. The flow of this model is illustrated in Figure 3.

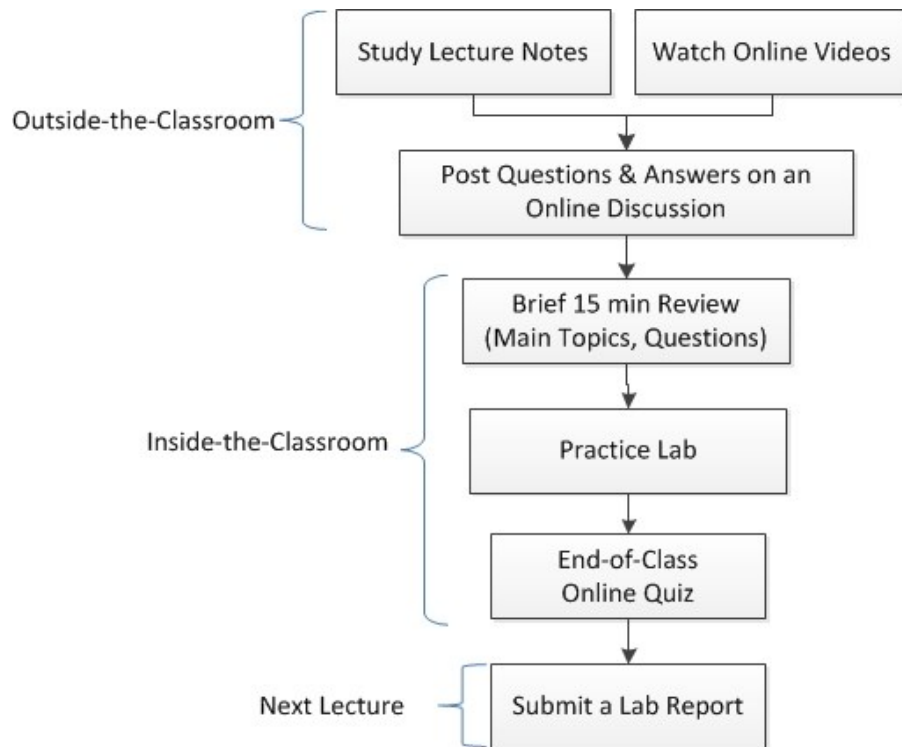


Figure 3- Hybrid Flipped Classroom Model

Implementation and Evaluation

This proposed flipped-classroom model was implemented in a multi-disciplinary Computational Thinking freshman-level course for engineering majors. This is a 4-credit hour course usually taught over 16-week semester in which engineering students are exposed, for the first time, to Computational Thinking and computer programming. The objective of implementing this model was to maximize the students’ “outside-the-classroom” learning experience in addition to providing in-class hands-on practice to a large population of engineering students. This hybrid model was implemented by flipping the classroom, adding an online-discussion, and providing a published lecture notes that goes hand-in-hand with all the topics covered in this course¹⁵.

To quantify the effect of this model, the performance of the students involved in this study was indirectly assessed in a pre- and post-assessment analysis. Within the first month of starting the course, the conventional classroom model was used and then switched to the new hybrid flipped classroom model for the remainder of the semester. A total of 25 students took part in the pre- and post-exams. The results of the pre- and post-exams for all the students are displayed in Figure 4. As shown, the students’ performance seemed to significantly improve using this model. However, the improvement between the pre-exam and the first post-exam was not very significant compared to the second post-exam. This is because the students had to adapt to the new model before they became more efficient in utilizing the online discussion component and the other components of this hybrid model.

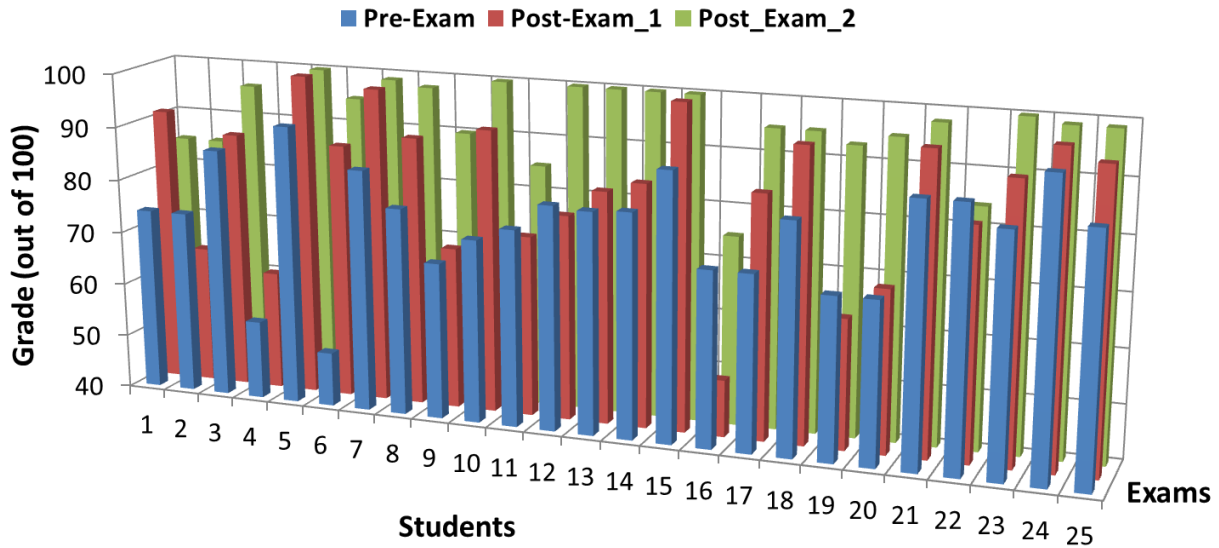


Figure 4- Students' Pre- and Post-Exams Grades

The normal distribution fit for the results of the pre- and post-exams is illustrated in Figure 5. As shown, these distributions indicate a difference in the overall mean and standard deviation of the pre- and post-exams' grades. An important observation is that the distribution of the first post-exam had a slightly higher mean value but larger standard deviation compared to the pre-exam. This was referred to as the implementation phase, since the students had to adapt to the new system. Not all the students in this phase were able to rapidly converge as indicated by the increase in the standard deviation of the students' grades. However, the detail guidance provided by the faculty was instrumental in helping the students utilize the full potential of this model. This supported the underlying hypothesis that the proposed flipped model can improve student performance and provide an effective learning environment outside and inside the classroom.

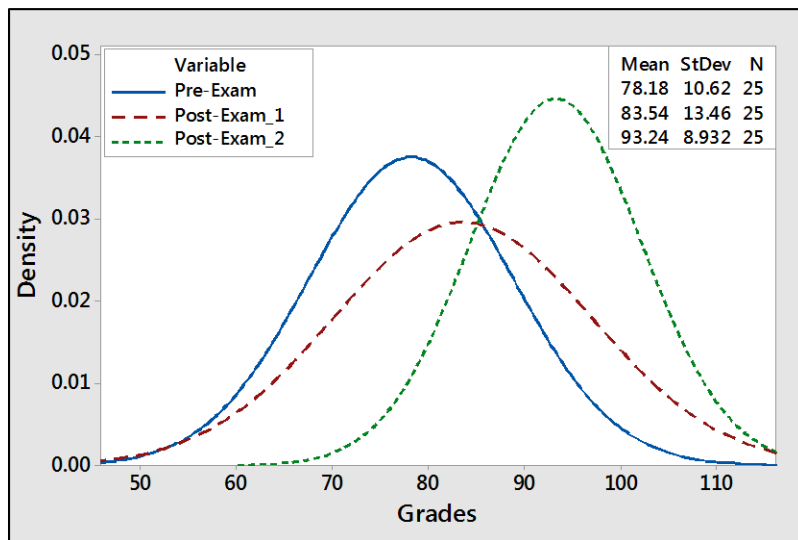


Figure 5- Fitting the Pre & Post Exam Grades into Normal Distributions

To verify and validate these findings, a thorough statistical analysis using the Minitab statistics software¹⁶ was conducted. Our null hypothesis stated that there were no statistical differences in the students grades obtained from the pre- and post-exams as a result of implementing this model. To test this hypothesis, we used the General Linear Model to analyze our data using a probability of error criterion with a significance level of 1% ($p=0.01$). The response variable for this analysis was the students' grades obtained from three exams (pre-exam, post-exam_1, and post-exam_2). Two main factors were considered in this analysis. The first factor is the treatment effect modeled by the difference in the pre- and post-exams' grades. The second factor is the student effect modeled as a nuisance or blocking factor. The three-level treatment was the effect of the hybrid flipped-classroom model before, during, and after implementation. The difference among students was considered as a blocking factor to eliminate their induced variability to the response variable. The analysis, as shown in Figure 6, generated a p-value less than **0.001** which is over an order-of-magnitude smaller than the **0.01** criterion for significance. Therefore, the null hypothesis can be rejected with a confidence level of more than **99.9%** and conclude that there is a statistically significant difference between the pre- and post-exams which validates the effectiveness of the proposed model.

General Linear Model: Grades versus Exams, Students					
Factor Information					
Factor	Type	Levels	Values		
Exams	Fixed	3	Post-Exam_1, Post-Exam_2, Pre-Exam		
Students	Random	25	Std_01, Std_02, Std_03, Std_04, Std_05, Std_06, Std_07, Std_08, Std_09, Std_10, Std_11, Std_12, Std_13, Std_14, Std_15, Std_16, Std_17, Std_18, Std_19, Std_20, Std_21, Std_22, Std_23, Std_24, Std_25		
Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Exams	2	2914	1456.76	28.58	0.000
Students	24	6526	271.91	5.33	0.000
Error	48	2447	50.97		
Total	74	11886			
Model Summary					
S	R-sq	R-sq(adj)	R-sq(pred)		
7.13944	79.42%	68.27%	49.75%		

Figure 6 – Outcome of the Two-way ANOVA Analysis

To further investigate this conclusion, a Fisher's comparison was conducted with a confidence level of **99%**. Figures 7 and 8 represent the outcome of the Fisher's comparison. The outcome of this comparison also supports our initial conclusion that the improvement in performance between the pre-exam and the first post-exam is not very significant due to its **99%** confidence level (Only **97.34%**). However the second post-exam demonstrate a significant improvement in the students' performance with a confidence level exceeding **99.9%**.

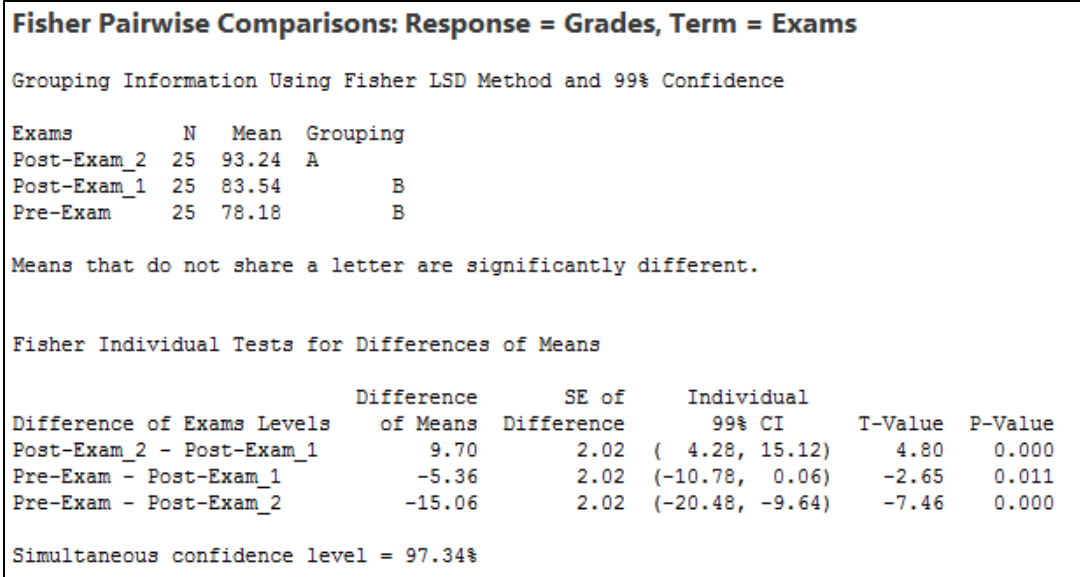


Figure 7 – Outcome of the Fisher’s Pairwise Comparison

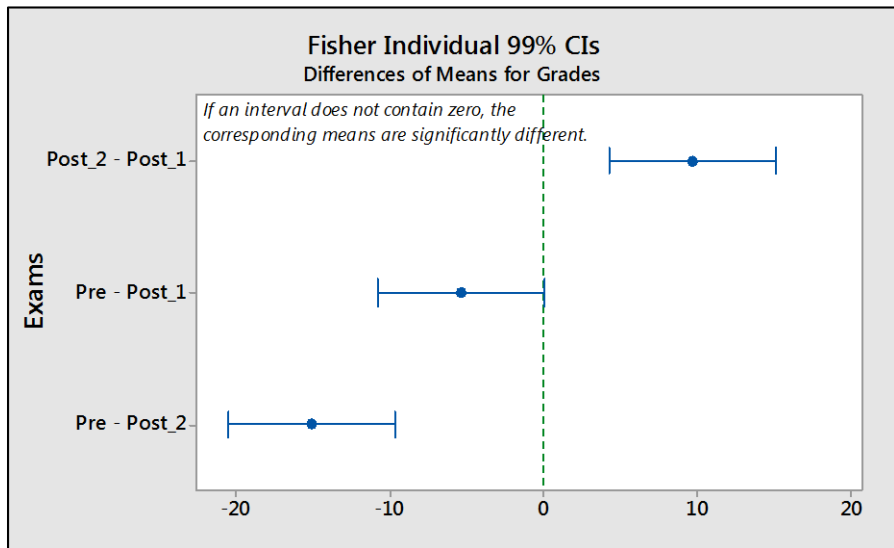


Figure 8 - Fisher’s Pairwise Comparison Graphical Representation of the Pre- and Post-Exams

Figure 9 illustrates the residual error plots of this statistical analysis. As depicted, the normal probability plot of the residual error followed a normal distribution. In addition, all the other plots supported this result indicating that the statistical model used was able to model the effect of the treatments very efficiently and the residuals in this case represent pure random noise.

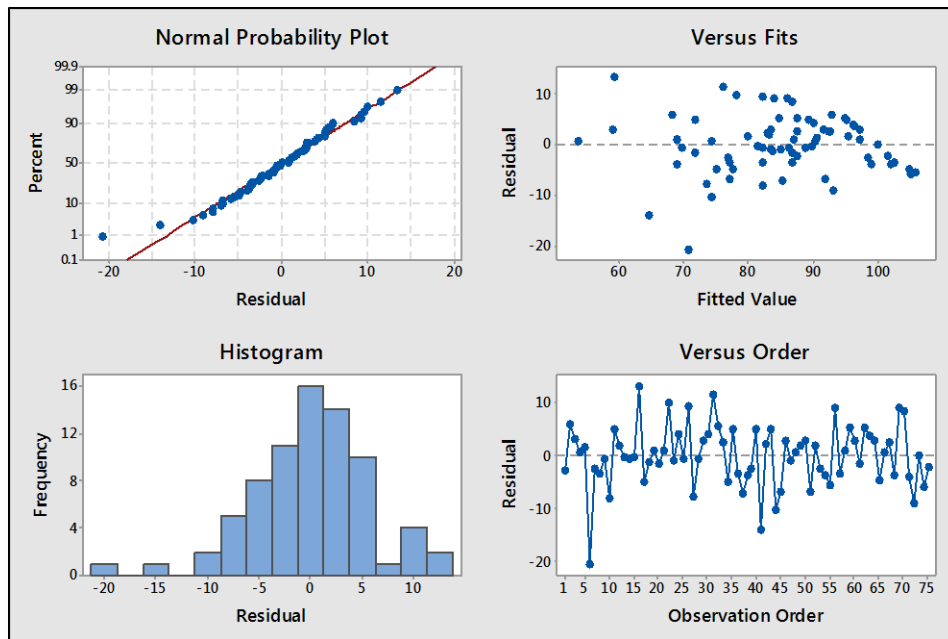


Figure 9- Residual Error Plots for the Pre- and Post-Assessment Analysis

In addition, a qualitative survey was administered towards the end of the semester to determine the students' satisfaction level with the hybrid flipped classroom model. To ensure anonymity, the survey was administered using Google Forms and was structured as follows:

- Rate the following statements using a scale from 0 to 10, 0 being absolutely disagree while 10 absolutely agree.
 1. I believe that this course (with the new instruction model) was advantageous over the traditional approach of instruction.
 2. I believe that the online discussion component was useful in the learning process in this model.
 3. I believe that the review at the beginning of every lecture was helpful in clarifying any outstanding misconceptions and allowed for more effective interaction with the professor.
 4. I believe that this course was challenging.
 5. Given the multi-disciplinary nature of the students of this course, I believe this model has encouraged multi-disciplinary team work.
 6. I believe that this model required more time spent outside-the-classroom studying.
 7. I recommend that this instruction model would become a standard across all the other courses.

Open-ended question:

- What did you like the most about this course?
- What would you like to see changed in this course and why?

The average results of the students' survey are summarized in Figure 10. In general, the results indicate the overall student satisfaction with this hybrid flipped classroom model compared to the traditional classroom models that they are enrolled in concurrently.

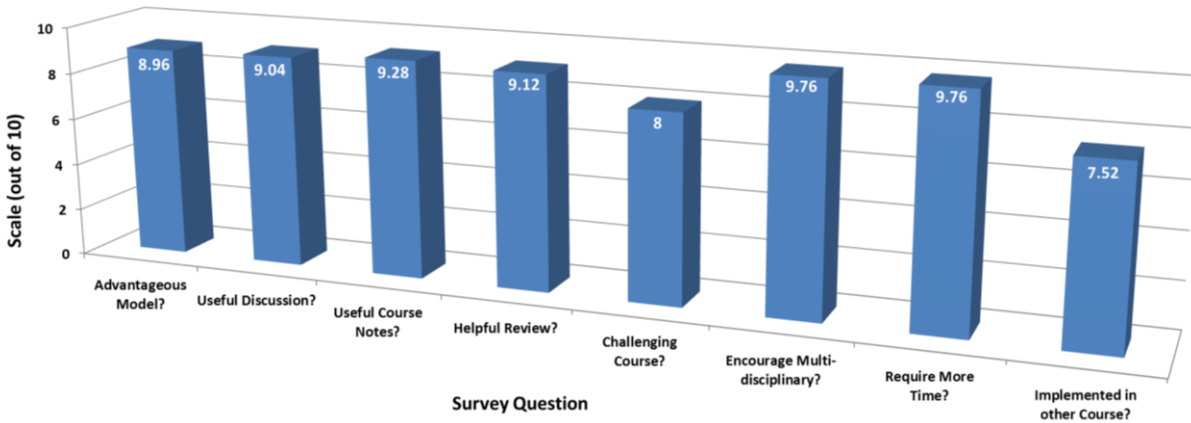


Figure 10- Students' Survey Results

Students agreed with 89.6% that they have seen advantages when using this model compared to the traditional instruction model. In addition, they also indicated with 90.4% that the online discussion component of this course was very helpful in improving the learning since it did create an interactive virtual learning environment outside-the-classroom. As for the published course notes, the students agreed with 92.8% that they were helpful in illustrating the various concepts and providing extra examples and practice problems. They also agreed with over 91% that the brief review session held at the beginning of every lecture was helpful in addressing any misconceptions that they might had. Since this model was fairly new, being able to adapt to its structure was by itself a challenge as indicated by the 80% response. Students also agreed with over 97% that this model encouraged multi-disciplinary team work and interaction within this course, which helped broaden the scope of knowledge application. On the other hand, the students admitted with 98% certainty that this model required more of the students' time outside-the-classroom. This was the most common student "dislike" or concern mentioned in this survey. With today's students' engagement in extracurricular activities, 75.6% approval rate to commit to this model is quite satisfactory for the purpose of this study.

Conclusions

In this paper, a novel hybrid flipped classroom model with an online discussion component was presented. The online discussion component of this model was able to create a virtual interactive peer-assisted learning environment outside-the-classroom. The supporting lecture notes were published especially to aid the delivery of the online video content of this course. This made the model hybrid in nature lecture notes/video-based flipped classroom. This seemed to appeal to a large population of engineering students' learning styles. In addition, this model provided a level of student ownership in the learning process which motivated them to perform better. The brief in class review represented a capstone reflection of what the students' were able to learn and even help clarify any outstanding misconceptions through an effective student-faculty interaction. The large part of the lecture time was spent on hands-on practice to reinforce the concepts and principles learned. Furthermore, a pre- and post-assessments of the students' performance were conducted. It was concluded that this model improved the students' academic performance since it maximized the outside-the-classroom learning and inside-the-classroom hands-on practice. In addition, this model provided a unique multi-disciplinary team work and

collaboration among students through online and in classroom discussions. All these results were inferred using a statistical analysis with a 99% confidence level.

The results of this study reinforced the importance of collaborative learning outside-the-classroom through virtual interactive environments. This active learning environment was able to improve the flipped classroom model and added to it a new learning dimension. The hybrid approach also helped cater to all the students' learning styles including the visual and verbal learners. However, one of the main challenges in implementing this approach is the students' resistance to change especially if this change is time demanding for the students' outside-the-classroom.

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