Classwork instead of Homework: A Novel Accelerated Summer Hybrid Lecture/Problem-Based Classroom Model

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Abstract

In short-term summer courses, students are expected to learn at a much faster pace than in a regular semester. Therefore, the instructor has to use different teaching techniques so students can succeed in such accelerated learning environment. In this paper, a novel approach to replace homework with classwork assignments in a summer course is presented. The proposed approach uses a hybrid model combining traditional lecture-based and problem-based instructions designed to provide students with instant formative feedback. Using this model, a typical 5-week summer term was rearranged to include 2-hour of classwork in a studio environment without affecting the teaching format of the course. Twice a week quizzes were administered to check student readiness and provide timely feedback about the progress of the student learning process. This hybrid teaching model was implemented in a senior level communication systems course offered in summer 2015 with 10 students enrolled in it. The effectiveness of this model was verified using multiple statistical assessment methods and compared with students in regular summer semester offering of the same course. Quantitative and qualitative analyses were conducted to assess the merit of the proposed teaching model. Assessment results obtained from the two groups showed that the students' performance in the accelerated summer course was significantly higher. This improvement was realized from the introduction of the 2-hour classwork which played a significant factor in increasing the overall students' success. Future work will investigate if this hybrid teaching approach can also be applied to other courses offered during regular academic terms.

Introduction

With the increasing emphasis on gaining co-op and/or internship experience, accelerated summer courses are becoming more essential to help the students maintain their progression towards graduation[1]. Accelerated summer courses usually span over a 5 week period compared to 16 weeks in a regular semester. In a study addressing the effectiveness of student attitude, knowledge and skill development in a 3-week summer term, 5-week summer term, and 15-week regular semester found no significant differences in term length of equivalent level of academic rigor[2]. Therefore, this intensive teaching schedule necessitates having daily lectures for each course in order to successfully cover the required curriculum. Even though this might help the students stay focused on the topic covered, the effectiveness of the homework component is questionable due to the course fast pace. It is well known that homework plays a vital role in engineering education since it can help students solidify their knowledge of concepts learned. Furthermore, graded homework assignments serve as a formative feedback tool for students if provided on a timely basis. However, a timely feedback is not easy to maintain in an accelerated summer courses and therefore could hinder the students' learning process.

Eliminating graded homework from regular semester courses and replacing it with study problems and quizzes to increase time efficiency and improve students' performance was previously proposed[3]. This model was based on the argument that homework grades don't correlate well with students' performance on exams[4]. Even though this model was reported to have helped students improve their performance. However, it was implemented in a military-based academy which requires a different type of commitment. Another study proposed flipping homework during a regular semester[5]. In this study, students were asked to first critic their homework while the instructor graded the students' ability to critically discuss their homework solution. This approach was reported to have improved the effectiveness of the homework component significantly. However, its implementation required sufficient time which is not readily available in an accelerated summer course. Therefore, in this paper, a novel approach to replace homework with classwork assignments in a summer course is proposed. The proposed approach uses a hybrid model combining traditional lecture-based and problem-based instructions designed to provide students with instant formative feedback. To the best of our knowledge this model has not been previously proposed in the literature.

Classwork Model

This hybrid problem-based/practice-based classroom model is mainly proposed for accelerated summer courses. The model was developed to improve the effectiveness of the homework component in such fast pace learning environment by replacing homework with classwork. Using classwork with the supervision of the instructor provides a collaborative problem-based learning environment with an instant formative feedback to students. This model also supplemented the traditional lecture with more active learning methods such as practice-based learning through the lab component. The main objectives of this proposed model is to:

1. help students better solidify their understanding of the topics being covered,
2. provide students with timely formative feedback, and
3. increase the students' overall performance and success in the course.

The proposed model is structured to have a 2-hour daily lecture and 4 additional 2-hour sessions alternating between classwork and lab. This model structure requires a total of 18 contact hours per week which is only viable within an accelerated summer course. Twice a week quizzes are used to provide formative assessment, to help adapt the learning environment to match tstudents' needs. The structure of this model is illustrated in Figure 1.

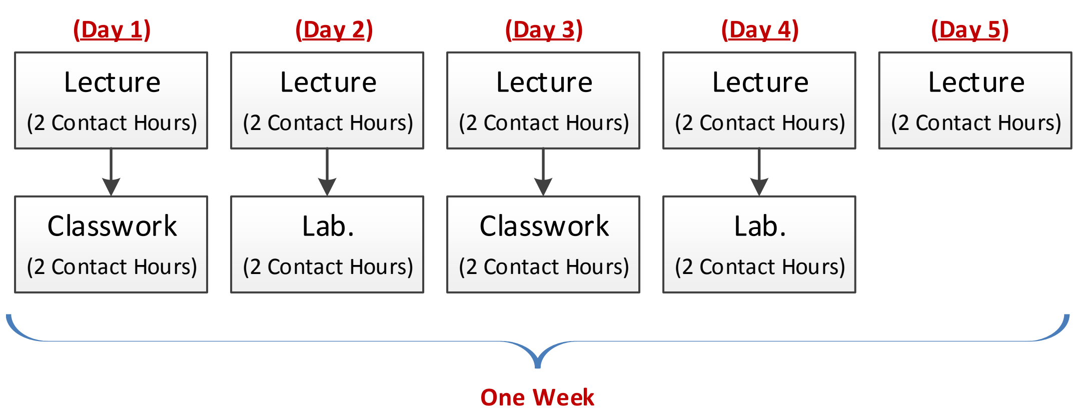

Figure 1- Hybrid Problem-based/Practice-based Course Model

After each lecture, the students are either asked to implement what was addressed using lab experiments or work in groups of two in a studio style setup to solve problems. In both lab and classwork sessions, students are required to have the instructor sign-off that they completed their work. The sign-off process included a discussion with the instructor which provided an instant formative feedback to the students. The proposed hybrid summer course model had the same number of contact hours as the traditional course model roughly around 80 contact hours per term. The main difference was in the way the contact hours were utilized. In the traditional summer course, each experiment was allocated two lab sessions, one session used for conducting the experiment while the other used to finalize the report. In this setup, homework was attempted outside the classroom. As for the hybrid model, only one lab session was allocated for each experiment, while the second lab session was utilized for the classwork. In this setup, the students had to prepare their lab reports at home. The two models consisted of the same number of lab projects, homework, exams, and quizzes with the same level of expectation.

Implementation and Evaluation

The proposed classwork model was implemented in a senior-level communication systems course. This is a 4-credit hour course with a lab component in which students are introduced to communication system principles such as analog modulation/demodulation and noise analysis. The course is by nature mathematically intensive and students usually struggle to understand the concepts being taught which may get worse in an accelerated summer course.

This accelerated summer course was covered over a span of almost 5 weeks with a total of 80 contact hours. The intensive teaching schedule necessitated having a daily 2-hour lecture and 2-hour labs 4 times a week to cover the required topics. This fast pace instruction limits the effectiveness of the homework component that provided delayed feedback. In this proposed teaching model, homework is replaced by classwork to provide just-in-time formative feedback to the students. This was implemented by alternating between lab and classwork sessions. After each lecture the students were either asked to implement what was addressed in lecture using lab experiments or to work in groups of two to solve between 5 to 8 problems. In both lab and classwork sessions, students were required to have the instructor sign-off on their work. This arrangement allowed for 10 lab and 10 classwork sessions creating a problem-based/practice-based hybrid learning environment. Our hypothesis indicated that diversifying the learning methods to cater to a wider range of students would ultimately result in better students' performance in accelerated summer courses.

To test this hypothesis and quantify the effectiveness of this model, two offerings of the same course were used as control and test groups. In these groups, the overall performance of each student involved in this study was assessed using a comparative statistical analysis. The control group was an accelerated semester offering of the communication systems course with the conventional homework component. As for the test group, it was also an accelerated semester offering of the same course but with the classwork component instead of the homework. A total of 16 students took part in the study, 6 students in the control group and 10 students in the test group. All the participants were male senior level students with the exception of one female student in the control group. The students' overall performance was measured by their final course grade which consisted of the assessment components shown in Table I.

Table I- Course Assessment Components and Grade Allocation

Assessment Component	Weight
Exam#1	20%
Exam#2	20%
Final Exam	30%
Lab Projects	15%
Homework/Classwork	10%
Quizzes	5%

The students' course grades were adjusted to account for the variation in students' scholastic aptitude. The students' cumulative grade point average (CGPA) (out of 4.0) and their course grade (out of 100) were used to calculate their differential grades as modeled in the following equation:

$$Diff.Grade = Course\ Grade - CGPA * 25$$

The normal distribution fit of the control and test groups' differential grade results is illustrated in Figure 2. As shown, these distributions indicate a significant difference in the overall mean and standard deviation of the control and test groups' differential grades. An important observation is that students in the control group were able to score on average 2.27 points higher than their expected academic performance quantified by their CGPA. While the students in the test group were able to score on average 12.71 points higher. In addition, the test group differential grades had less variability compared to the control group which was inferred from the test group low standard deviation. This supported the underlying hypothesis that the proposed model can improve student performance and provide an effective learning environment inside the classroom.

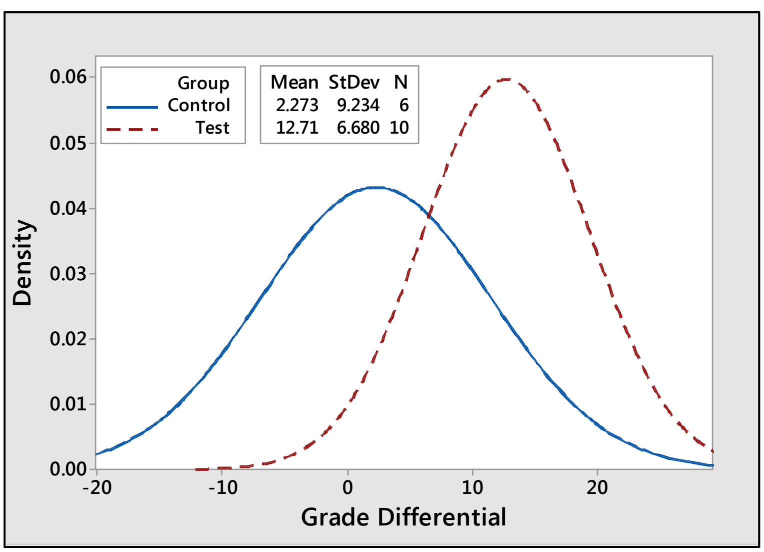

Figure 2- Fitting Differential Grades for the Control and Test Groups into Normal Distributions

To verify and validate these initial findings, a thorough statistical analysis using the Minitab statistics software[6] was conducted. Our null hypothesis stated that there were no statistical differences in the students' differential grades obtained from the control and test groups as a result of implementing this model. To test this hypothesis, we used the one-way analysis of variance (ANOVA) to analyze our data using a probability of error criterion with a significance level of 5% (p=0.05). The response variable for this analysis was the students' differential grades obtained at the end of the course. The main factor considered in this analysis is the treatment effect modeled by the students' differential grades in the control and test groups. The two-level treatment was the conventional homework (control group) versus the hybrid model using the classwork (test group). The difference among students was considered by factoring in their cumulative GPAs in the calculation of their differential grades to eliminate the induced variability in the response variable.

The analysis provided in Figure 3, generated a p-value equal to **0.02** which is less than the **0.05** criterion for significance. Therefore, the null hypothesis indicating that there is no significant difference between the groups was rejected with a confidence level of **98%.** This concludes that there is a statistically significant difference between the control and test groups which validates the effectiveness of the proposed model. In addition, since the sample size used in this analysis was small, the Cohn size effect was calculated. The calculated Cohen size effect (*d)* of **1.358** indicates that the proposed approach in fact has a significantly large effect on the students' performance despite the small sample size.

General Linear Model: Grade_Diff versus Group

Factor Information

Factor	Type	Levels	Values
Group	Fixed	2	Control, Test

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Group	1	408.5	408.47	6.91	0.020
Error	14	827.9	59.14		
Total	15	1236.4			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
7.68999	33.04%	28.25%	10.25%

Figure 3 – Outcome of the One-way ANOVA Analysis

To further investigate this conclusion, a Fisher's comparison was conducted with a confidence level of **95%**. Figures 4 and 5 represent the outcome of the Fisher's comparison. The outcome of this comparison further supports our initial conclusion that the improvement in performance between the control and the test groups is significant. In addition, it indicates that the performance of the test group was significantly better than the control group with a confidence level of **98%**.

Tukey Pairwise Comparisons: Response = Grade_Diff, Term = Group

Grouping Information Using the Tukey Method and 95% Confidence

Group	N	Mean	Grouping	
Test	10	12.7100	A	
Control	6	2.2733		B

Means that do not share a letter are significantly different.

Tukey Simultaneous Tests for Differences of Means

Difference of Group Levels	Difference of Means	SE of Difference	Simultaneous 95% CI	T-Value	Adjusted P-Value
Test - Control	10.44	3.97	(1.92, 18.95)	2.63	0.020

Individual confidence level = 95.00%

Figure 4 – Outcome of the Fisher's Pairwise Comparison

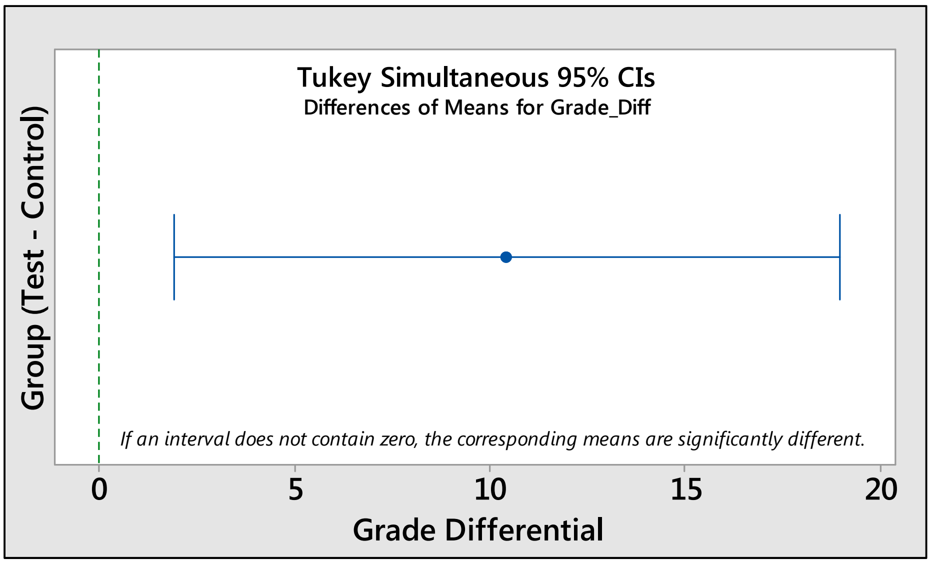

Figure 5 - Graphical Representation of the Fisher's Pairwise Comparison

To test the model's goodness-of-fit, the probability plots of the statistical analysis results were presented in Figure 6. This figure shows that the differential grades for both the control and test groups followed the straight line representing the Normal distribution. The goodness-of-fit was quantified with p-value much higher than 0.05 and a low adjusted Anderson-Darling statistic (AD) less than 0.2. This is another indicator that the students' differential grades in both groups are normally distributed.

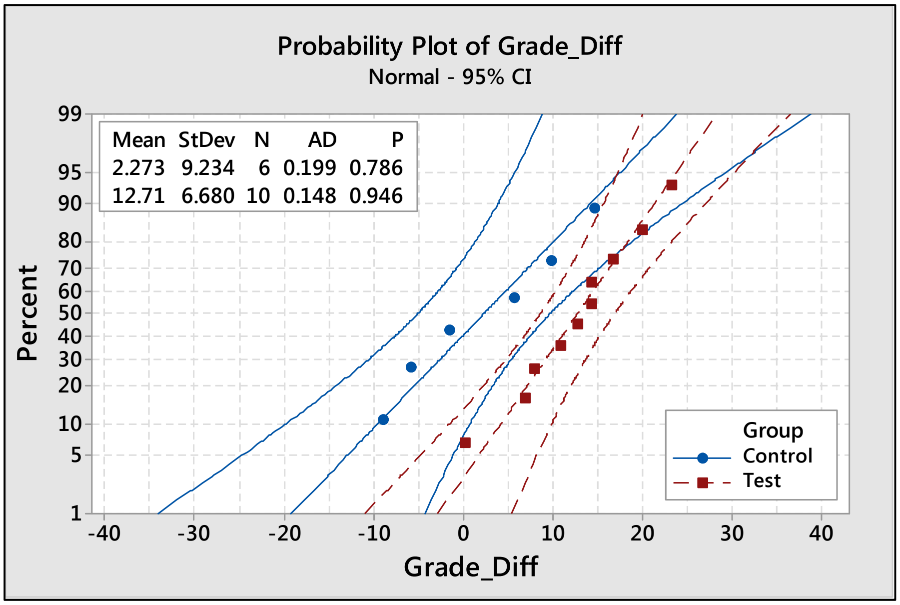

Figure 6- Probability Plot for Differential Grades Analysis for the Control and Test Groups

Figure 7 illustrates the residual error plots of the statistical analysis. As depicted, the normal probability plot of the residual error followed a normal distribution. In addition, all the other plots supported the result indicating that the statistical model used was able to capture the effect of the treatments very efficiently and the residuals in this case represent pure random noise.

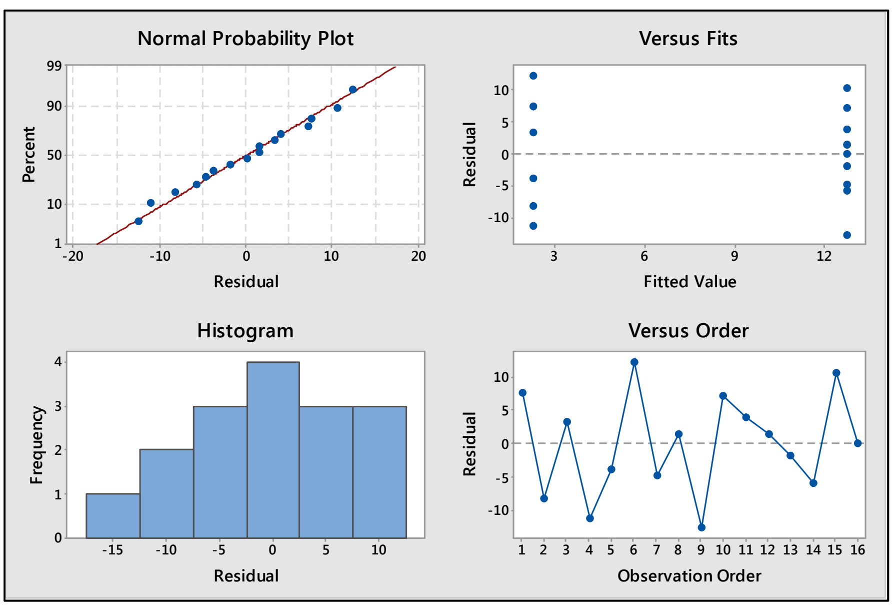

Figure 7- Residual Error Plots for the Assessment Analysis

In addition, the students' level of satisfaction with the proposed course model was reflected in their final course evaluation administered towards the end of the semester. Samples of these responses are as follows:

"I loved the examples and class work. Definitely made the content more understandable."

“*I liked best in this course the in-class homework where the instructor was there to answer questions this helped me understand the concepts a lot better*.”

Conclusions

In this paper, a novel hybrid lecture-based/problem-based classroom model for accelerated summer courses was presented. A typical summer teaching week using this model consists of five 2-hours lectures, two 2-hours classwork sessions, and two 2-hours lab, with classwork and lab sessions offered in an alternating fashion. The classwork component of this model with the supervision of the instructor was able to create a collaborative problem-based learning environment with an instant formative feedback to students. The lab component was able to create a practice-based learning environment that helped students apply what they learned and solidify their understanding. In addition, the hybrid nature of this model appealed to the students’ wide range of learning styles. The results of this study highlighted the importance of the homework as a learning tool. In addition, it showcased the effectiveness of using classwork in lieu of homework in accelerated summer courses. This hybrid approach also helped students better solidify their understanding of the topics being covered, provided students with timely formative feedback, and increased the students’ overall performance. These results were inferred using a statistical analysis with a 98% confidence level. For future work, this hybrid model will also be implemented in a regular course semester since the contact hours are the same. However, there is a need to rearrange the regular semester course schedule to facilitate such implementation.

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