Best 2019 Zone IV Paper : Assessing Student Assessment in a Flipped Classroom

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Abstract

One of the many advantages of a flipped classroom is that it provides more time for instructors to work directly with students. Assessing students with in-class quizzes and/or exams effectively mitigates this advantage by replacing time spent on direct student/instructor interaction with non-interactive assessment. While assessment using quizzes and exams do not provide a direct learning experience, many students place a high value on such assessment techniques distributed throughout the course as opposed to having them concentrated at the end of the course.

This paper describes a novel implementation of an intermediate digital design course taught in a flipped-type classroom using a studio-type format. The overall goal of this approach was to determine the efficacy of dedicating a portion of class time to student assessment distributed throughout the course. At the beginning of the course, students chose whether they wanted their course grade weighted on distributed assessment or have their assessment more heavily weighted on final exams. This approach effectively gave students who chose their assessment concentrated on final exams a potential advantage in that it allowed them a greater opportunity for instructor interaction compared to the other students since they could obtain help with course material while other students were taking exams and quizzes. This paper compares the overall performance of both sets of students in order to determine which assessment approach was more effective in helping the students learn the course material. This paper also addresses the question of whether distributed assessment provided true "academic" benefits or whether it simply acted as a mechanism to encourage students to remain current with the course's subject matter.

Introduction

Teaching innovations such as the flipped classroom and the studio format are a result of instructors seeking methods to improve their ability to teach. The literature generally agrees on the overall improvement in student achievement provided by these approaches, despite having the benefits being downplayed by published results that are largely based on heuristic observations and qualitative surveys rather than empirical validation with quantitative data[5].

While the flipped classroom does seem to have many advantages, it also contains issues that may actually hinder student performance[3]. Issues such as student resistance to the model and time required by the instructor to make the model effective can have detrimental effects on the efficacy of the approach. A survey of flipped classrooms in engineering education concludes that context and instructional design are also important factors in student performance[3]. In that a significant part of instructional design involves assessment, we should consider how the methods we use to determine student achievement affect the levels of achievement we are attempting to determine.

The many aspects of instructor feedback also have a direct effect on student performance. Though the literature documents that constant and varied forms of feedback is beneficial to students[2], this is somewhat of a generality because it does not consider important issues of individual students. Students are not static homogeneous test subjects; academic workload, outside employment, and personal matters constantly change, so what works for a student one term may not always work for that student. In order to properly support student learning, instructors must not only consider various modes of student learning for students[6], but also should consider the various real-life challenges that students typically face.

Research associated with the flipped classroom typically compares the performance of students in both flipped and traditional classrooms. These studies base the validity of their results on comparing student achievement using equivalent assessments techniques. Shifting the assessment focus can change student attitudes in ways such as encouraging them to take more responsibility for their own learning[7]. Thus, "one size fits all" approach to assessment may not be the ideal approach to optimizing student performance.

This paper describes an experiment where we assess how giving students flexibility in their assessment affects their overall performance. Our approach is to give students a choice as to the frequency and style of their assessment. Specifically, we give students the option of having weekly quizzes affect their course grade or have most of the course assessment be in the form of final examinations. Our goal is to determine if giving students an option as to how they will be assessed can benefit their overall performance. A key element of our approach is to provide all students with various forms of immediate feedback regarding their performance. Our hope is that this flexibility in assessment will help students balance the demands of learning the course material with other aspects of their lives.

Background

We constantly tweak our approach to assessing students in hopes of finding the magic approach that best supports students but does not generate an unreasonable amount extra work for us. Our past assessment approaches included weekly quizzes, one, two, and three midterms per quarter, and various combinations of quizzes and midterms. We noted that students tended to procrastinate and then cram before the exam or quiz. We eventually switched to only giving final exams; these exams then determined 80% of the final course grade. Primarily assessing students at the end of the course seems appropriate because that is when students are ultimately responsible for knowing the course material. Moreover, it makes no sense to allow a mid-course assessment to negatively affect a student's final grade.

Assessing students at the end of the course has several benefits. First, it provides the instructor more time to work directly with students. Using class time for assessment undermines some of the advantages of both the flipped classroom and the studio format. Second, it gives students more time to work with the subject matter before they are tested on it. Finally, writing only final exams frees the instructor from writing and grading exams and quizzes throughout the quarter, which is time that can be spent helping students. This is an important distinction for instructors who write original exams and do their own grading (a practice actively discouraged by our institution).

Course Description

We conducted the experiment on two sections of the CPE 233, our second course in digital design. CPE 233 covers aspects of computer architecture, intermediate digital design, and assembly language programming[4]. The course requires students to model the RAT microcontroller (MCU) using VHDL and then use it to help them learn assembly language programming. The RAT MCU is an 8-bit MCU with an assembly language containing 50 instructions. CPE 233 is taught as a studio course in a laboratory setting with a format that closely resembles a flipped classroom. The sections met for two hours, three times per week, for ten weeks. Class meetings comprised of short lectures to answer questions, outline the current topics, and introduce experiments. Although we provided few video lectures, the lab experiments and assigned programming problems required a significant amount of time outside of class to complete. Our format thus falls into the board category of the flipped classroom[1].

The lab component of the course consisted of ten experiments. Seven experiments involve the modeling of the RAT MCU and synthesizing it onto an FPGA-based development board; three experiments involve programming the RAT MCU to solve given problems. Each experiment required students to submit a report that included solutions to a hardware and a firmware-based design problem, and ten short-answer questions. Students worked in groups of two or three (a mix of quiz and non-quiz students); each group submitted one lab report for each experiment as well as a final design project.

Students choosing the quiz option had to stay with that choice for the entire quarter. On quiz days, quiz-taking students migrated to one side of the laboratory, which allowed the instructor to help the non-quiz taking students. Table 1 shows the weightings for the two options. The course's studio format allows instructors to give two finals (on different days), which we label as the "lab" and "lecture" finals. The two-hour lab final exam contains approximately 30 short-answer questions while the three-hour lecture final exam contains seven design-type problems.

	Weighting	
Assessment Item	**Quiz**	**No-Quiz**
Quizzes	22.5%	n/a
Lab Reports	20.0%	22.5%
Final Project	7.5%	7.5%
Lab Final Exam	20.0%	25.0%
Lecture Final Exam	30.0%	45.0%

Table 1: Weightings for quiz and no-quiz options.

Each of the ten quizzes had a similar format. The first page was a hardware-based or an assembly language problem while the second page contained three short-answer questions. The quizzes matched the format of both the lab reports and the two final examinations in that the first page

was a design-type problem (similar to the lecture final) and the second page had short answer questions (similar to the lab final). The quizzes were closed notes, but students could use an instructor provided cheatsheet. Students were given approximately 25 minutes to complete the quiz. We provided all students with immediate feedback as we graded all quizzes and lab reports, and returned to students the next class meeting. We gave all students in the course access to the quizzes and solutions.

Experiment Statistics

A total of 49 students completed the course; 26 students chose the non-quiz option while 23 students chose the quiz option. Figure 1 shows the final course grade distribution for both the non-quiz and quiz options. The final average GPAs were 2.38 and 2.21 for the non-quiz and quiz taking students, respectively.

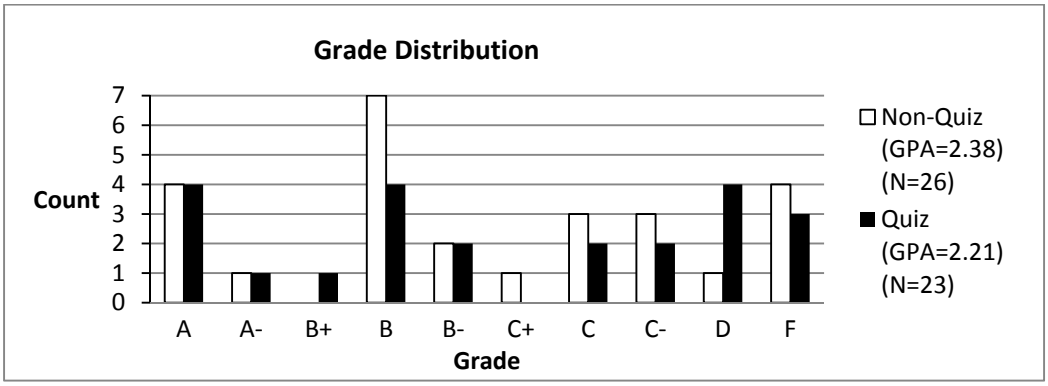

Figure 1: Course grade distribution.

Figure 2 shows a chart of the average quiz scores for the course. The trendline in Figure 2 shows that the average scores slightly decreased during the course. Table 2 shows how quiz-taking students performed both with and without the quiz option. The quiz option had a relatively small benefit for students (1.19%); approximately one third of the quiz-taking students had higher course point totals when their course totals were calculated as a non-quiz option.

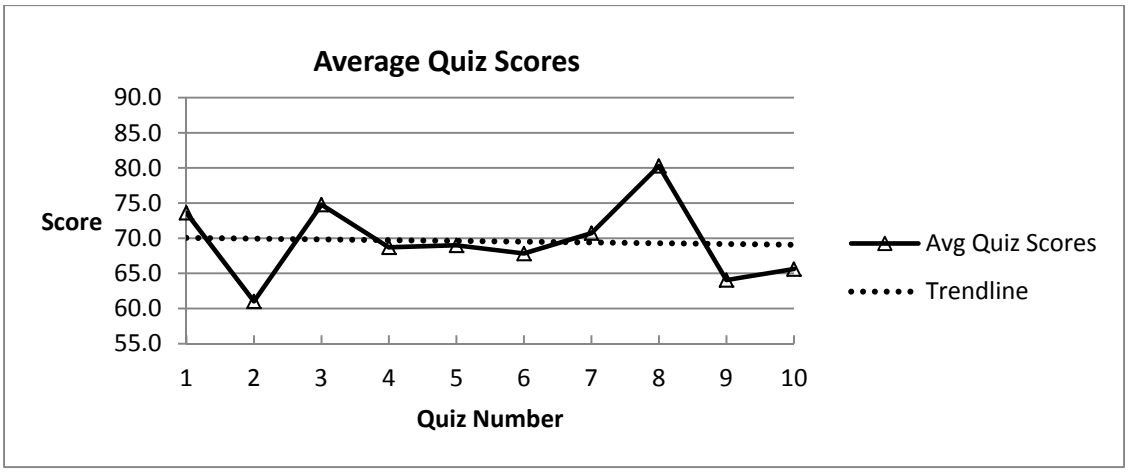

Figure 2: Average quiz scores and trendline.

students with higher non-quiz calculation	avg total with no-quiz calculation	avg total with quiz calculation	difference
31.5%	69.07%	69.89%	1.19%

Table 2: Data associated with quiz-taking students.

Table 3 provides various data associated with the non-quiz and quiz grading options. The data in Table 3 shows that students not taking the quiz performed better in each of the listed categories. The overall point total for the course was 70.72%, which resulted in a final GPA of 2.27. This GPA is relatively low compared with to both the students cumulative GPAs and the GPA in the CPE 133 (the first digital design course), which supports the fact that CPE 233 is a challenging course. The data in Table 3 indicates that the non-quiz students performed better than quiz-taking students. The issue here is whether we can identify a specific group of students who were significantly helped or hurt by the quiz vs. non-quiz option.

Item	Non-Quiz	Quiz	Diff	Total
Average Lab Final Scores	65.27%	59.83%	8.33%	62.45%
Average Lecture Final Scores	68.42%	66.39%	2.97%	67.47%
Average Final Point Total	71.47%	69.89%	2.21%	70.72%
Average Final Course GPA	2.38	2.21	7.14%	2.27
Average CPE 133 GPA	2.91	3.02	3.64%	2.96
Average Cumulative GPA	3.15	3.18	0.94%	3.17

Table 3: Various data for quiz and non-quiz options.

Figure 3 shows the average GPAs for CPE 133 on the chart's left vertical axis and the average GPA assigned to those students in CPE 233 on the right vertical axis. We divide the students into six groups based on the quiz and non-quiz option and their letter grades in CPE 133. The slope of the lines in Figure 3 show the difference in performance, where equal slopes indicate that they quiz vs. non-quiz option students performed equally. The confounding factor here is the fact that our group of CPE 233 students had six different CPE 133 instructors.

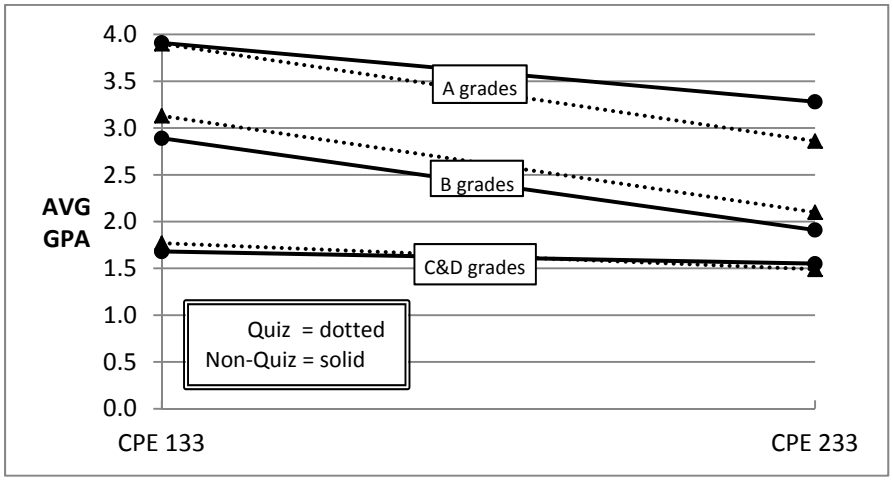

Figure 3: Average CPE 133 GPA vs. average CPE 233 GPA.

Figure 4 shows the average cumulative GPAs for students on the chart's left vertical axis and the average GPA assigned to those students in CPE 233 on the right vertical axis. We divide the students into six groups based on the quiz and non-quiz and based on their cumulative GPA ranges (these ranges roughly follow the A, B, and C&D grades from Figure 3).

Figure 4 shows a notable difference in the lower GPA range, where students taking the quiz performed significantly better than the non-quiz students. Despite the fact that the N value (number of students per category) is low for both sets of students in this range (three quiz and three non-quiz students), no non-quiz students taking students passed the course while two quiz-taking students did pass. There are two confounding factors in this comparison. First, CPE 233 is a sophomore-level course and there are relatively few major courses to influence the cumulative GPA. Second, the cumulative GPA includes transfer students who often have more general education courses included in their cumulative GPAs compared to non-transfer students. Table 4 shows the data set used to generate the charts in Figure 3 and Figure 4.

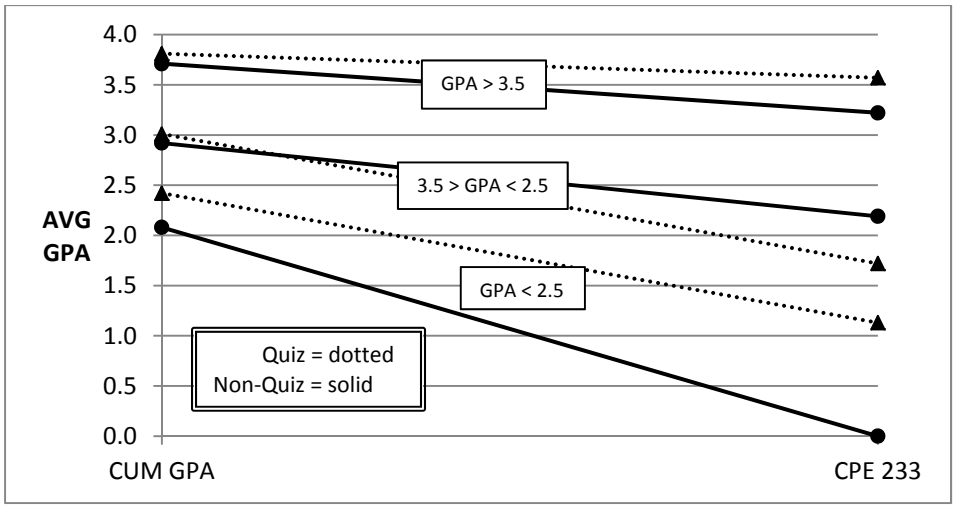

Figure 4: Average cumulative GPA vs. average CPE 233 GPA.

		Non-Quiz			Quiz		
	Data Description	**CPE 133 GPA**	**CPE 233 GPA**	**N**	**CUM GPA**	**CPE 233 GPA**	**N**
Letter Grades	A	3.91	3.28	10	3.90	2.86	9
	B	2.89	1.91	8	3.13	2.10	7
	C & D	1.68	1.55	8	1.77	1.49	7
GPA Ranges	4.0 ≥ GPA ≥ 3.5	3.71	3.22	11	3.77	3.63	7
	3.5 > GPA ≥ 2.5	2.92	2.19	12	2.93	1.40	13
	2.5 > GPA ≥ 0.0	2.08	0.00	3	2.42	1.13	3

Table 4: Associated data for Figure 3 and Figure 4.

We have taught CPE 233 several times using the heavily-weighted final exam approach. Accordingly, Figure 5 shows the course offering with the quiz option (Fall 2017) and the past four course offerings without the quiz option. The course material was essentially the same for all course offerings, but there was a significant difference in enrollments between the Fall 2017 offering and previous offerings. Previous enrollments were all above 60 students compared with 51 students in the Fall 2017 offering. The difference in enrollment is significant because instructor resources are spread less thin with smaller enrollments, which allows instructors to better support students (a notion is well-understood by instructors but consistently overlooked by academic administrators).

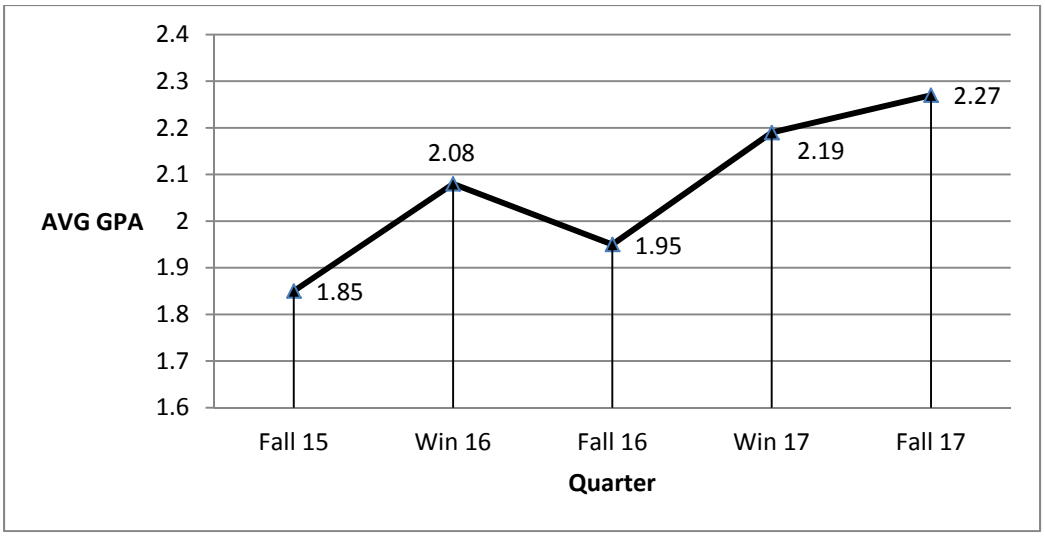

Figure 5: Graph showing average GPAs for past offerings of CPE 233.

Student Comments

We asked both sets of students several questions regarding their choice of assessment options. We asked these questions late in the course as part of the last quiz and lab final exam. Table 1 lists the questions, results, and a representative set of comments. Worth noting here is how students interpreted the word "performance". Most quiz-taking students commented on both their self-projected grade in course as well as the knowledge they felt they acquired in course. Specifically, most of quiz-taking students stated that the quizzes hurt their grade but helped them learn the course material. The data actually shows that the average quiz scores were higher than both the average lab and lecture final scores for quiz-taking students.

Option	Question	Answer	Representative Student Comments
Quiz	Do you feel taking the "quiz" option helped you, hurt you, or had no effect on your overall performance?	**Helped: 87.0%**	"kept me on track" "motivated me to keep up the studying of material every week" "forced me to review and study throughout rather than just at the end"
		Other: 13.0%	"hindered my overall performance" "I would have done better if quiz material was one week later"
	If you had it to do all over again, would you still select the "quiz" option for this course?	**Quiz: 81.8%**	**(Responses similar to "Helped" above)**
		No Quiz: 18.2%	"I felt I needed more time to understand topics" "it would allow me to focus on concepts of course and not have to worry about quizzes"

Non-Quiz	If you had it to do all over again and knowing what you know now, would you take the "quiz option" or not?	**No Quiz: 70.8%**	"the labs were hard to stay on schedule" "the labs were enough to learn the material well" "it allows you to gather the whole concept of the class before being tested on it" "Seems to add a lot of stress every week, especially when we're trying to get our labs to work"
		Quiz: 29.2%	"for extra practice learning up to the exam to keep me honest about studying" "I could have learned from my mistakes more with the quiz option" "quizzes would better prepare me for the final and give me a reason to study throughout the quarter" "helped cement the ideas week by week rather than scrambling to remember everything last minute"

Table 5: Questions asked of students.

Conclusions

The data shows that non-quiz taking students performed better in all tracked categories than their quiz-taking cohorts. Specifically, the course GPAs were 7.14% higher, the lab final exam score was 8.33% higher, and the lecture final was 2.97% higher; the final course point total (which included lab report scores) was 2.21% higher. These results are partially supported by the fact that quiz taking students started the course with higher values in both the previous digital design course's GPA and their cumulative GPAs. The data also shows that lower-performing students performed better with the quiz option. Students in the lower cumulative GPA range who took the quizzes had a higher course pass-rate than the non-quiz students in the same range.

Similar to other flipped classroom research, the strength of our results is primarily qualitative. A majority of students reported that if they had to choose again, they would not change their assessment option (87% of quiz-taking students and 71% of students not taking quizzes). Moreover, 82% of quiz-taking students reported that the quizzes helped them learn the course material. These relatively high percentages indicate that the making the quizzes optional added a flexibility that seemed to support student learning, as indicated by the fact that the final GPA for the quiz-optional offering of the course was notably higher than previous course offerings. In all likelihood, the overall student performance in the course would have been lower if there were not quizzes for quiz-taking student and had the non-quiz students been forced to take the quizzes. But then again, attributing this result to the flexible assessment is somewhat optimistic because the course enrollment in the optional quiz version of the course was roughly 15% lower than the average enrollments of previous course offerings.

Our original concern of this approach was that quiz-taking students would have less class-time to work with instructors. This concern seems unfounded in that none of the quiz-taking students

reported this as an issue. We also noted that the non-quiz taking students were unusually quiet (did not seek instructor help) while other students were taking quizzes.

While these overall results of this experiment seem to show that non-quiz students had a performance advantage, we believe that giving students a choice in the weightings of their assessments provided benefits for both sets of students. The overall flexibility of this approach allowed students to have the option of using weekly quizzes to inspire them to stay currently with course material, or choose to have more time to digest the course material before they were tested on it. While using quizzes to inspire students to study is not an official course objective, students seemed to feel that it helped them learn the course material.

The extra instructor effort required to provide this level of flexibility in course assessment was minimal. While it did require extra time to write and grade quizzes, this time was quite reasonable, especially in light of the notion that the most students appreciated the overall flexibility of this approach, and their overall performance was greater than previous offerings of the course. As of this writing, we are repeating this experiment for the current CPE 233 course in order to re-visit the validity of our results.

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