ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

2017 Pacific Southwest Section
Meeting: Tempe, Arizona Apr 20 Paper ID #20662

COMPARISON OF TRADITIONAL, HYBRID AND FLIPPED CLASSROOM FOR WATER RESOURCES DESIGN COURSES

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Abstract

As technology becomes readily available to students and faculty, there are techniques that can be used to deliver material to students outside the traditional classroom environment. Using interactive white board, screen capture and audio recording software, lecture material and practice problems can be delivered to students outside of classroom instruction.

Over the course of several years, Engineering Hydrology, a senior level civil engineering design course, has experienced dramatic redesign. The course which initially was taught in a traditional face-to-face (F2F) lecture has also been taught through hybrid-asynchronous (HA) as well as flipped classroom models. This study looks at comparing the three teaching pedagogies (F2F, HA, and flipped) in terms of student engagement and student performance/comprehension.

Initial results show that student performance in F2F and flipped classrooms had comparable exam and overall grades. In the F2F and flipped classrooms less than 20% of students received a deficient grade on the midterm and less than 39% received a deficient grade on the final. In the flipped classroom a considerable amount of time was spent having class discussions and group-based problem solving activities. This increased students' interaction with their faculty and peers during class, which helped reduce confusion on complex topics. Students performed significantly better on out of class homework assignments (increase of 10%), increasing their overall grade, and resulting in no students receiving a C-. Currently, there is no statistical significance between the F2F and the flipped classroom environment. On the other hand, students in the hybrid course performed below students in the F2F and flipped modes. Approximately, 32% of the students earned a deficient grade on the midterm and 39% on the final exam. Thus, student engagement is essential for student performance and comprehension. We observed that reduced contact time decreased students will to learn the material. In addition, hybrid instruction requires more faculty guidance in the online media through discussion boards, online office hours and immediate feedback on student performance.

Introduction

As faculty, we teach material to students the same way the material was taught to us, in a traditional face-to-face (F2F) lecture style classroom. It is the form of instruction that we are most familiar with. However, F2F instruction is not the most effective teaching strategies for engaging student learning (2014)[1]. This is because students learn from a variety of learning-styles based on how they receive and process information. Since the 1970's research have looked at various ways students learn and there are many models that can be used. To address the learning needs of engineering students Felder and Silverman (1988 and 1993)[6,73] developed a learning style model (refer to Table 1).

Table 1- Learning styles and definitions

Category	**Preferred Learning Style**	**Student Type**
Perception	Sensory	Concrete Thinkers, Practical, Oriented towards facts and procedures
	Intuitive	Abstract thinker, innovative, Oriented toward theories and underlying meanings
Input	Visual	Prefer visual representations of presented material
	Verbal	Prefer written and spoken explanations
Processing	Active	Learns by trying things out, enjoy working in groups
	Passive	Learns by thinking things through, prefer working alone or with a single familiar partner
Understanding	Sequential	Linear thinking process, learn in small incremental steps
	Global	Holistic thinking process, learn in large leaps

As engineering educators in a F2F we focus on: Intuitive, Passive, Sequential and Verbal learning (1988)[6]. When one refers to the preferred learning styles of students, it can be overwhelming to see how to engage all students. Thus, the goal of the project was to look for ways that we can actively engage more students in the lecture. F2F allows for minimal discussion, problem solving and discussion in the allotted contact time. In this mode, students are passive learners, expecting to be given answers to questions on future homework assignments and tests. In preparation for a given assignment, students would line up during office hours each quarter asking similar questions about a new concept they needed to understand to complete the assignment. We spent countless hours helping students outside of the classroom during office hours and via email communication to complete the assignments.

We would prefer to have active learners participating in a classroom. We wanted to shift the focus to the student and away from the lecture content. Most students at our university are defined as Generation Y (Millennials), born between 1982 to 2003. Wilson and Gerber (2008)[9] recommend that to engage with Millennials instructors need to enhance clarity and increase student participation. In 2015, we started creating videos delivered via YouTube that students watched prior to class. The goal was to create a classroom environment where students could

ask questions, review assignments and work in teams. We tested teaching in a hybrid-asynchronous (HA) and flipped classroom lecture environment to see the impact technology has in our course.

Previous work assessing impacts of flipped teaching have been mixed. Wilson (2014)[8] observed that the flipped format improved students' attitudes toward a statistics class commonly disliked by students. Mason et.al. (2013)[5] observed that struggled with the format initially but later had a favorable opinion of it. In the same study, students performed at or slightly better students in similar courses (in terms of quizzes and exam grades). Another study showed significant improvement in student performance while also showing increased opportunities for group learning and oral communication experiences.[4] The work by Bishop & Verleger (2013)[2] summarizes various other publications that show student performance in flipped courses overall is not significantly different from student in traditional lectures. Only one of the studies surveyed by Bishop and Verleger (Daly & Foley, 2006)[3] successfully assessed student performance across an entire term (semester). Therefore more work needs to be done to assess the impact of the flipped learning environment.

A HA course is defined by our institution as an instruction that uses technology to replace at least one face-to-face meeting during the term. Rather than attend class students are directed to a learning experiences delivered through technology. In the context of this current study, the term HA specifically means that half of the class meetings were replaced with online learning experiences so that students attended class only once per week.

In the context of the current study the term 'flipped' classroom is defined as a course in which the vast majority of the lecture material is given outside of class. Students spend most of the time in class working on problems, or working in groups to apply the instructions received before coming to class. Numerous studies have shown

For both the HA and flipped formats the lecture material was organized on Blackboard (our institution's learning management system). The videos created were posted on YouTube and links to the specific video were then inserted into the lecture introduction on Blackboard. Out of class work was also distributed to the student via Blackboard immediately following the lecture material.

Methodology

The following outlines the definition of the teaching technique used in Engineering Hydrology, an upper division design course in civil engineering. Over the course of 4 years data was collected to compare tradition, hybrid and flipped classroom environments.

Traditional Face-Face (F2F) Classroom - course meets face-to-face for all of the course contact hours prescribed.

- Students attend face to face class for 3 hours and 40 mins per week over 10 weeks
- Instructor teaches material traditionally on a whiteboard with theory, examples and occasional group work.

- Discussion occurs but it is minimal since students are being introduced the material for the 1st time.
- Students complete homework and projects outside of class time.
- Instructor grades assignments outside of class to provide students feedback.

Hybrid-Asynchronous (HA) Classroom - Course uses both classroom and online instructional modes and meets face-to-face for 25% -75% of the course contact hours prescribed by the course type and units.

- Students watch pre-lecture videos each week to prepare them for the face to face meeting.
- Students attend face to face class for 1 hours and 50 mins per week over 10 weeks to work in groups on problem solving activities.
- Students complete homework and projects outside of class time.
- Instructor grades assignments outside of class to provide students feedback.

Flipped Classroom - Course uses both classroom and online instructional modes and meets face-to-face for the entire scheduled course contact time.

- Students watch pre-lecture videos regularly to prepare for face to face meeting.
- Students attend face to face class for 3 hours and 40 mins per week over 10 weeks
- Prior to group work, instructor reviewed concepts from the pre-video and had active discussion with students on the topics presented.
- Student worked in teams on problem solving activities. During the class instructor and students discussed the problems and solutions were presented.
- Student complete homework and projects outside of class time.
- Instructor graded assignments outside of class to provide students feedback.

As we looked to create this new instructional form within the department students' familiarity with HA and flipped modes of instruction was not clear. The university has a few general education courses offered online, but many students continue to choose F2F environments. The department does not offer any fully online courses, and during the evaluation period for this study only one other course from the department was taught in a flipped format. Other faculty members are testing the use of technology, but that has not been completely documented. The main difference between the HA and flipped classroom was a reduction in contact time and discussion.

Data/Results

Five to seven sections of Engineering Hydrology are offered within an academic year taught by a combination of full time and part time instructors. The data and results are only based on the sections offered by a single full time professor, the primary author, within the department over the past four academic years (2013-2014, 2014-2015, 2015-2016 and 2016-2017). The method of instructional delivery varied thus providing a comparative evaluation of student performance. During AY 2013-14 and AY 2014-15 students were instructed using the F2F format, HA format

was used during AY 2015-16, and during AY 2016-17 students were instructed using the flipped format. We selected multiple section from each delivery method: 3 sections for F2F (71 students), 2 sections for HA (66 students) and 2 sections for flipped (66 students) for comparison.

In all three teaching methodologies students were graded based upon categories and percentages outlined in Table 2.

Table 2 – Grading Summary

Categories	**Percent of Overall Grade**
Homework	20%
Quizzes and Participation	10%
Design Project (Team Work)	15%
Midterm Exam	25%
Final Exam	30%

We collected data for all assignments submitted to the instructor for assessment and grading. All assignments, quizzes and exams had comparable difficulty. We conducted the performance analysis for each of the three cohorts of students based upon average performance on a specified topic and the standard deviation from the mean.

Table 3 provides a comparison summary of the statistical results.

Table 3 – Statistics based on Grading Categories

Categories	**F2F**		**HA**		**Flipped**	
	Avg	**Std Dev**	**Avg**	**Std Dev**	**Avg**	**Std Dev**
Homework	79.0	19.0	81.7	17.2	87.3	12.0
Quiz and Participation	80.1	17.2	78.5	11.9	79.1	12.2
Design Project	82.4	7.8	83.9	8.4	86.8	6.8
Midterm Exam	83.1	9.3	75.7	11.4	81.8	9.1
Final Exam	76.4	12.1	74.8	11.6	76.1	13.2
Overall	82.1	10.4	82.0	7.5	84.5	7.4

The results show there was no significant difference when comparing the F2F, HA and flipped instruction modes in the overall grade. In the flipped classroom the student homework grade significantly improved. We attribute this to the significant increase of contact time the faculty had with the students over the term the class was taught. In addition, students could clarify questions and work in teams on problem solving prior to attempting the out of class homework problems.

The standard deviation about the mean is lowest for most categories for the flipped model, suggesting less variability of student performance. Again, we feel that this occurred due to the significant increase of contact time between students and the instructor. In addition, since pre-

lecture videos were used students could be introduced and reintroduced to the material throughout the quarter.

To further identify the effects of F2F, HA and flipped classrooms we looked at midterm and final exam grade distribution. Both midterm and final exams were designed similarly, regardless of instructional delivery. The exams contained both conceptual and problem solving questions. Students were assigned a letter grade based on a traditional plus and minus letter grading system (see Figure 1 and Figure 2).

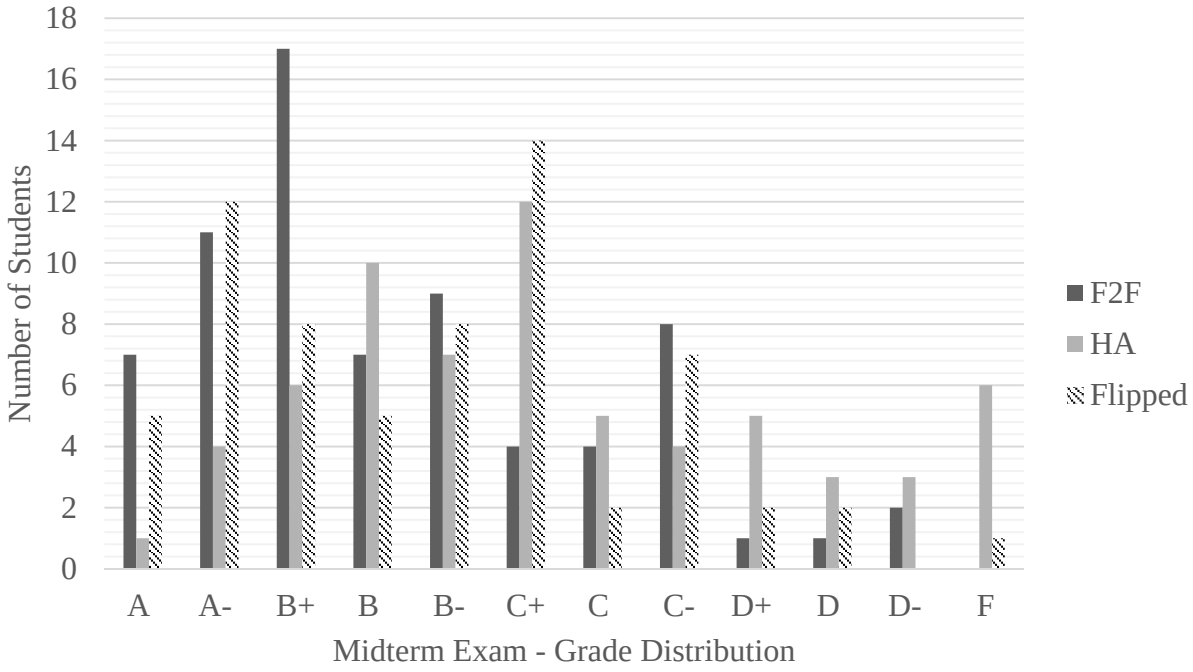

Figure 1 – Midterm Exam Distribution

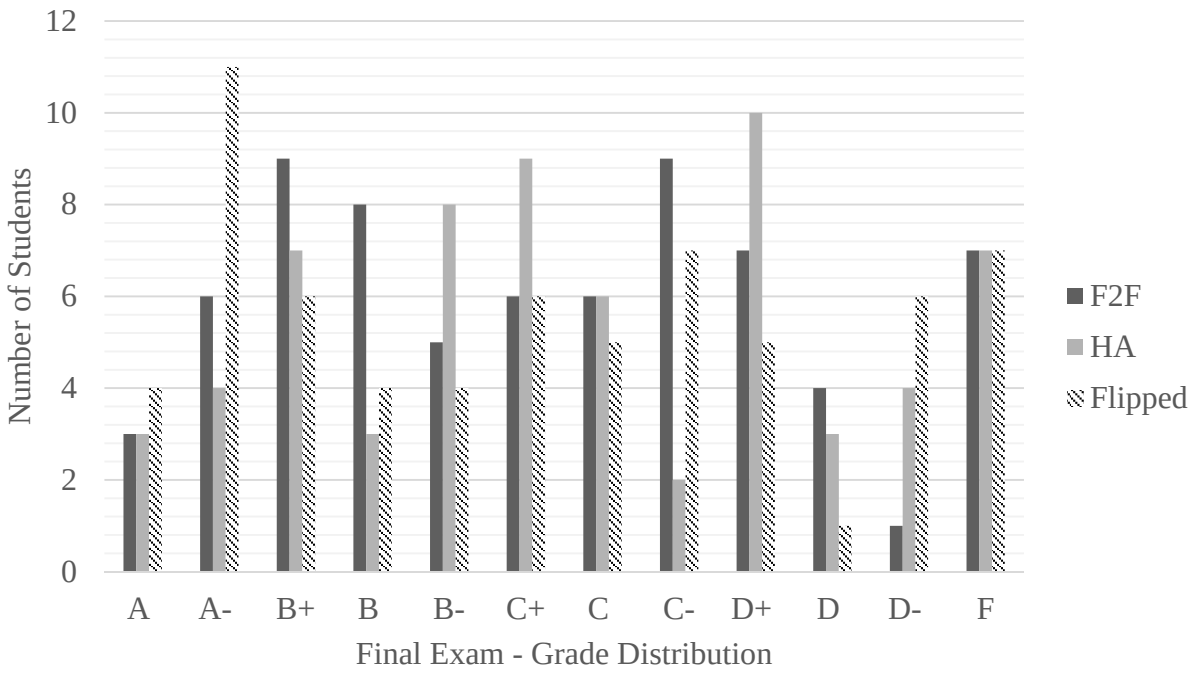

Figure 2 – Final Exam Distribution

For students to graduate they must have an overall and core grade point average of a 2.0 which equates to a C average. The results show that for the midterm exam F2F (59 students) and flipped (54 students) classroom environments 83% and 84% of students respectively received a C or better. However, in the HA (45 students) 68% of the students received a C or better. During the final exam the overall student performance was similar regardless of delivery method: F2F 61% (43 students), HA 61% (40 students) and 61% (40 students) flipped.

To further identify the effects of F2F, HA and flipped we looked at the overall grade distribution. After grades were computed based on Table 2, each individual student was assigned a letter grade based on a traditional plus and minus letter grading system (see Figure 3).

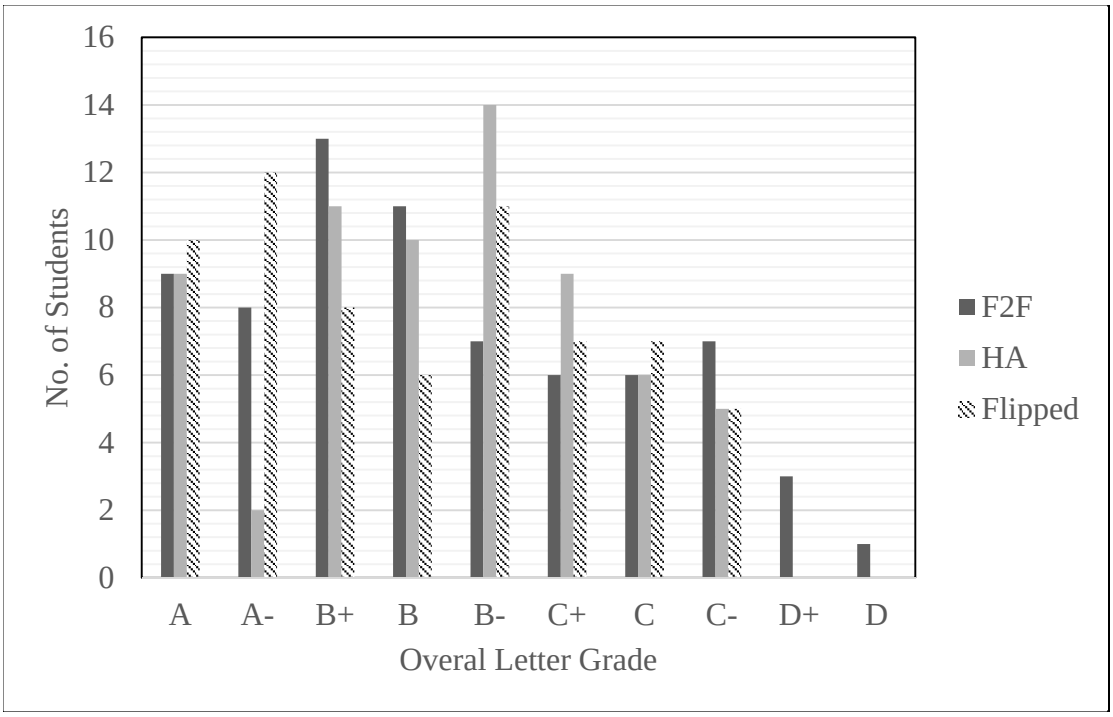

Figure 3- Overall Student Letter Grade Distribution

Figure 3 indicates that no students received a final grade less than a C- in the hybrid and flipped classroom. We attribute this to each student receiving the same instruction on the lecture material through the video lessons. In addition, students had the opportunity in both HA and flipped formats to work in teams solving class problems and discussion these problems with the instructor as questions arose. The additional requirement of solving problems in class prepared them for their out of class assignments. In the flipped classroom students performed significantly better on homework assignments, which explains why they received higher overall grades within the course.

An unexpected benefit to providing the flipped environment was that it was more enjoyable. The additional discussion and in-class problem solving sessions provided more opportunities to witness 'a-ha' moments in students. It also allowed greater, positive interaction among the students. The quantity of these interactions were only measured anecdotally. No direct measurement was taken on whether or not students enjoyed the course more than students in the F2F format courses.

Two (2) students in the HA format did express disappointment that the course only met twice per week. There were three (3) who said the liked only meeting once per week was beneficial to them. Overall we observed less energy in the room during the HA format classroom – similar to a F2F lecture.

Summary

Utilizing technology to develop videos for students to use outside of the classroom, has also provided consistency in lecture material across multiple sections. This has allowed for an opportunity to engage with students on hydrology concepts that traditionally created confusion in a F2F format. Developing in class worksheets for team work and problem solving has resulted in increased student engagement – asking more in-class questions where all students can gain from the questions. The course redesign for Engineering Hydrology over the past four academic years shows that student performance has not changed significantly when it comes to overall grades. However, the variability in student performance has decreased, thus indicating that there is significant amount of consistency in how material is being delivered and retained by the learners. The HA classroom showed that students performed poorly in exams due to the significant loss of contact time with the instructor and their peers. Additionally the HA and flipped formats exposed students to further teamwork, leadership and communication skills development. Finally, as a surprise benefit, replacing lecturing with in-class work and discussion has become personally rewarding.

As we continue to develop the flipped classroom for Engineering Hydrology we hope to increase students' conceptual understanding. The current practice has been to develop discussions centered on conceptual ideas, but this has not been effective. New strategies are being planned for implementation in spring of 2017. In addition, indirect surveys were conducted to evaluate student attitudes toward the HA and flipped environments which were inconclusive. Thus, a detailed analysis on attitudes are planned during the 2017-2018 academic year. In addition, as more faculty embrace technology, more students will have prior experience with a HA or flipped classroom model and thus prior knowledge will be evaluated during the 2017-2018 academic year.

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