2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39350

Exploring how Different Instructional Methods Compare to Improve Student Performance and Satisfaction in an Online Environment.

Mr. Michael Roberts, University of Florida

Currently, I work as a Technology Coach for a research grant. I have research experience in numerous fields including Magnetic Barkhausen Noise (MBN) in HY80 steel, Engineering Education, Artificial Intelligence (AI), and my current senior design project involves designing a sensor to detect volatile gases in moon regolith (moon rock). long with my research experience, I have developed my programming and computational skills which have assisted me in performing and teaching aspects of data analytics and data science. My diverse research background has allowed me to learn about different areas of engineering and I can use everything I have already learned and apply it to the next job, project, or task.

Investigating the effects of course modality on student performance and satisfaction in online learning.

Abstract

The objective of engineering education is to explore and establish effective instructional strategies in higher education that can enhance student learning outcomes. Due to the COVID-19 pandemic, numerous students have had to transition from traditional in-person learning to online learning. While online classes have been available prior to the pandemic, their widespread implementation presents a new set of challenges in terms of teaching and learning styles. As students have diverse learning styles, it is crucial to recognize a model that sets them up for success. Studying the impact of instructional techniques on student achievement and satisfaction in online education can play a crucial role in determining the optimal approach for students. This research aims to investigate the effects of course modality on student performance and student satisfaction in online learning. This study involved comparing and evaluating two distinct instructional techniques, traditional and flipped, within an online learning environment. The study analyzed student performance and course evaluations from an introductory materials science and engineering course at a university in the Southeastern United States. Initial findings indicated that the average exam scores between the traditional and flipped setups did not differ significantly. Further examination of the exam results was conducted to identify areas of difficulty and develop an enhanced approach for delivering course material. Additionally, the study assessed student satisfaction levels through analysis of course evaluation data.

1. Introduction

Engineering education involves researching and establishing effective instructional methods in higher education. In higher education, instructors often teach larger numbers of students than in traditional classroom settings. Some universities that enroll tens of thousands of students have lecture halls filled with hundreds of students taking the same class, so teaching in the most effective way is important. Given the diversity of college campuses, determining the most effective instructional approach for every student can be challenging. Therefore, evaluating student performance and satisfaction through multiple measures is necessary to assess the effectiveness of an instructional method.

The Covid-19 pandemic has compelled millions of students worldwide to shift to online learning. This transition can pose challenges and drawbacks, particularly for students who lack experience with online courses. However, for other students, the transition to online delivery carries advantages. Reported advantages of an online learning environment can include a more comfortable learning environment, saving of time that would otherwise be spent traveling, and the encouragement of students asking questions with an online chat feature [1],[2]. Disadvantages of an online learning environment include network instability, unilateral interaction, and reduced concentration [1],[2]. Technology offers great advantages, but sometimes it does not work; network instability is a great hinderance to online learning. For example, students can miss course material during an online lecture when the screen freezes or

when the instructors voice cuts in and out. Participating in an online class may also feel unilateral in terms of interaction with others and the instructor, interaction through an online environment and in-person are different things [1], [2]. In an online setting it is very easy for students to become disengaged. Often students' cameras and microphones are off, which can result in reduced concentration. This environment makes it likely for a student to pull out their phone or disengage from class [1],[2],[3].

Student engagement can be described as a psychological investment in learning what is being presented. The involvement of students in the learning process can be characterized as a cognitive and emotional commitment to understanding the material presented. Factors that can affect students' perceptions and engagement in online learning can consist of one's attitude/motivation, self-efficacy, and experience with technology. How a student views and values their education will influence how seriously they interact with an online course [3]. For an online class, it is up to the student to participate in class and interact with the course.

Student engagement can be enhanced by improved instructional techniques. Methods of teaching can be broken down into four categories; instructor centered, interactive, individualized, and experiential [4]. Instructor centered learning primarily involves one-way communication from the instructor to the students. Questions from instructor to the whole class is also a form of an instructor centered strategy; this method primarily facilitates passive learning for the student which is what the traditional classroom is based on [4]. Interactive strategies are based around class discussion and group assignments. Students are forced to interact with each other and the instructor in figuring out the task or concept at hand. This method promotes active learning and is heavily relied on in the flipped classroom model. Individualized strategies run off the notion that students learn at different paces, and these strategies are heavily based on progress in sequential steps. Experiential strategies involve putting a student in the field or simulated environment that is similar to the environment they could potentially be working in. This type of strategy is very common when it comes to internships, laboratory settings, and apprenticeships.

The traditional model of teaching in an online environment does not aim to actively engage students. Students join class online, listen to a lecturer present course material during class, and are expected to study and practice outside of the 'classroom'. In class learning activities may include reading texts, listening to lecture, and brief, small classroom discussions [5]. The model relies heavily on the instructor to facilitate learning which has advantages and disadvantages. The flipped classroom model in an online environment is a teaching style in which students join class to practice the content that they are taught outside of the 'classroom' [6]. Rather than the conventional method of attending lectures in class followed by practicing the material at home, students are required to watch instructional videos online at home. During class time, they engage in discussions and exercises to reinforce and apply the concepts covered in the videos. [7]. The flipped classroom approach is based on the engagement of higher cognitive thinking and problem solving with others during class. Early models of this were developed by Wavloord and Anderson in 1998 and Lage, Platt, and Treglia in 2000 [8]. There has been conflicting research regarding which instructional strategy is better as some suggest it facilitates better learning while other studies suggest it does not [9],[10],[12].

Student satisfaction can be described as a student's attitude or perspective toward their educational experience [11]. Student satisfaction is an essential aspect of education as it reflects the level of contentment and fulfillment students feel with their academic experience. When

students are satisfied, they are more likely to be engaged and motivated in their learning, leading to improved academic performance. On the other hand, dissatisfied students may become disengaged and may struggle to succeed in their coursework. Additionally, satisfied students are more likely to have positive attitudes towards their school, instructors, and peers, which can foster a positive learning environment. Hence, it is important that students within an education system are satisfied with their learning experience [11]. Factors that affect student satisfaction include type of course, class size, attendance, motivation, interaction, and collaboration [11],[12].

In the current paper, the effectiveness of different instructional methods is assessed by analyzing student satisfaction and performance as key indicators. The study employs a mix of qualitative and quantitative data to measure both student performance and satisfaction.

2. Theoretical Underpinnings

It is crucial to explore and establish the theoretical foundations of various instructional methods and their interconnectedness. The traditional classroom model is rooted in the principles of behaviorism, whereas the flipped model is based on the tenets of constructivism. Behaviorism is a learning theory which is has been around since the 19th century and was initially developed by B.F. Skinner J.B. Watson and has been further investigated by many others since [13]. The theory is based on the idea that learning is developed through interacting with environmental stimuli[14]. Skinner believed all learning was measurable through observing changed behavior and important factors within behaviorism include connecting stimulus, response, and conditioning [14]. In terms of conditioning, behaviorists stress the need for reward for a desired behavior and punishment for undesired behavior. These aspects of learning are heavily implemented in a traditional classroom setting - students are observing an instructor give them information and when it is time to get tested on the information, a good grade would be a reward and a bad grade would be a punishment. Receiving good grades motivates a student to keep grades high, while a bad grade motivates a student to try harder.

Constructivism is a more recent learning theory than behaviorism initially developed by Piaget and later developments were added by Vygotksy and Bruner, and others [13],[14],[15]. Constructivists' say learners are not passive recipients of information, but that they actively construct their knowledge in interaction with the environment and through the reorganization of their mental structures [14]. The theory suggests students' need to process new information based off what they already know [15]. In a classroom setting, the learning is active; students are collaborating, practice problems are being used, and questions are being asked. This allows students to challenge what they know because if something is not consistent with a previous understanding, changes in mental process can be made [15].

3. Methodology

The current study aimed to explore the impact of course modality on student performance and satisfaction in the context of online learning. To provide a comprehensive understanding of the topic, a literature review was conducted, delving into the learning theories, instructional strategies, and learning environments pertinent to the research. In an online setting, the effectiveness of the traditional and flipped models in an introductory materials science and

engineering course was assessed by analyzing student performance and satisfaction. Student performance data consists of grades on quizzes, tests, and other activities. The data was analyzed by filtering and categorizing it based on exams, question type, and chapter. Similarly, student satisfaction data was analyzed using Likert scale survey questions and student responses. The differences between the instructional strategies were determined by analyzing the data on student satisfaction in terms of Likert scale questions and student responses. The overall process is shown in Figure 1.

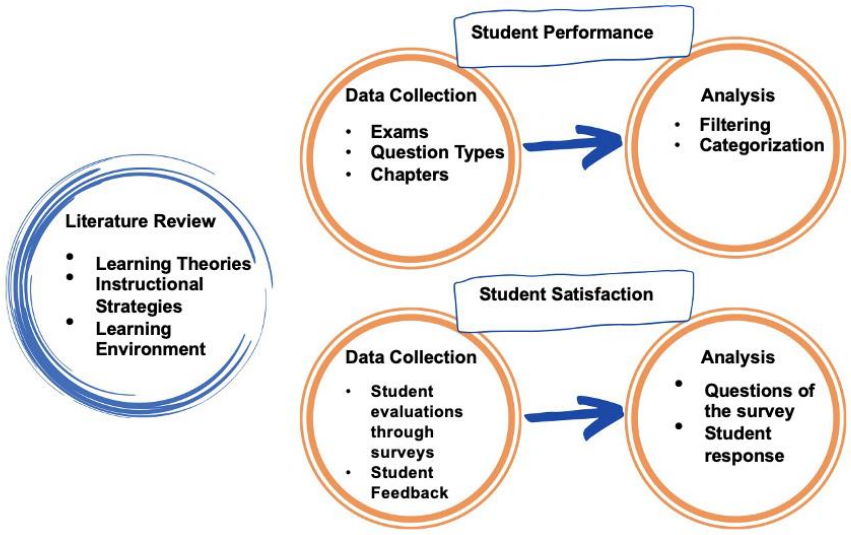

Figure 1 - Graphic displaying methodology of the research process and how each metric was measured.

Student performance data was collected through Canvas which is a software application used by many universities to facilitate communication and learning between students and instructors. All assignments, quizzes, discussions, and exams can be posted on canvas. Student grades were extracted from Canvas and analyzed for trends in student performance. Data for student performance was collected from exams and then further filtered and categorized by which exam, question type, and the chapters the questions came from.

Student satisfaction data was collected through GatorEvals, which are surveys implemented by the University of Florida to their students. Evaluations exist for each course a student takes, and they are highly encouraged to be completed but not required. Quantitative and qualitative data are included in these evaluations. Quantitative data comes from Likert scale type questions which ask the student how much they agree or disagree with a certain aspect of the course. Qualitative data from the evaluations involve open-ended questions that allow the student to type any answer they desire. Data for student satisfaction was collected from the student evaluations, and then Likert responses were compared.

Instructional strategies for the flipped class differed from the traditional class. A student's final grade in the flipped class was comprised of 10% Perusall reading, 10% Perusall lecture, 25% in-class exercises, 40% midterm exams, and 15% for the final exam. Perusall is a software that aims to facilitate an in-depth reading experience that encourages students to annotate as they read. For the traditional class, final grade consisted of 5% quizzes, 10% homework, 10% in-class

exercises, and 75% exams. Major differences between the instructional strategies include the use of Persuall, assigning homework, and the overall weight of the exams.

4. Results and Discussion

a. Student Performance

The distribution of exam performance comparing flipped and traditional classes is seen in Figure 2. For the traditional group (A), the average of the three exams was taken for each student. The weighted average exam performance for the traditional class had a mean of 80.14%. For the flipped group (B), the weighted average of the five midterms was taken for each student. The weighted average exam performance for the flipped class had a mean of 79.28%, which was not statistically different when comparing the two instructional strategies. However, the traditional class's distribution of scores differed from that of the flipped class in that there were less scores in the 80%-90% range. This led to the flipped group exam having a more normal distribution.

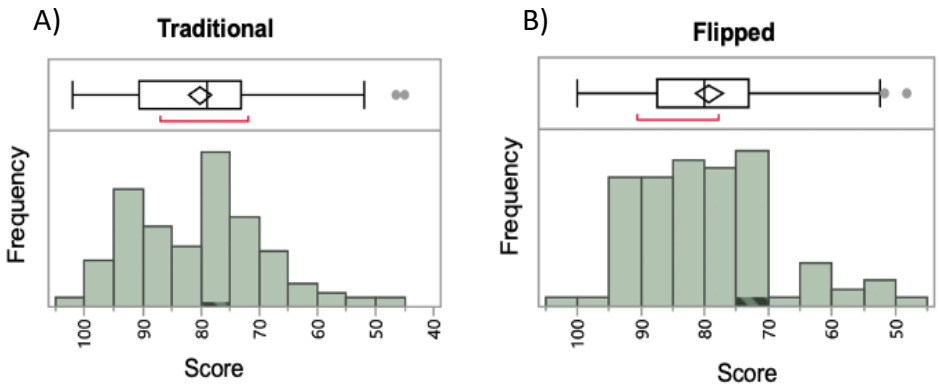

Figure 2 – Distribution of exam performance in the traditional class (A) and flipped class (B).

The challenging questions from all the exams taken are displayed in Figure 3, indicating the respective chapters they correspond to. The figure takes into account all of the questions missed on each test, grouped by chapter, and compared by teaching method. Out of all the identified challenging questions, the percentages of those questions were distributed by chapter. Figure 3 allows one to determine which chapters were more difficult for students and which instructional strategy they came from. Both instructional strategies offer benefits and drawbacks according to the chapters taught as some chapters may be taught better by a certain instructional strategy.

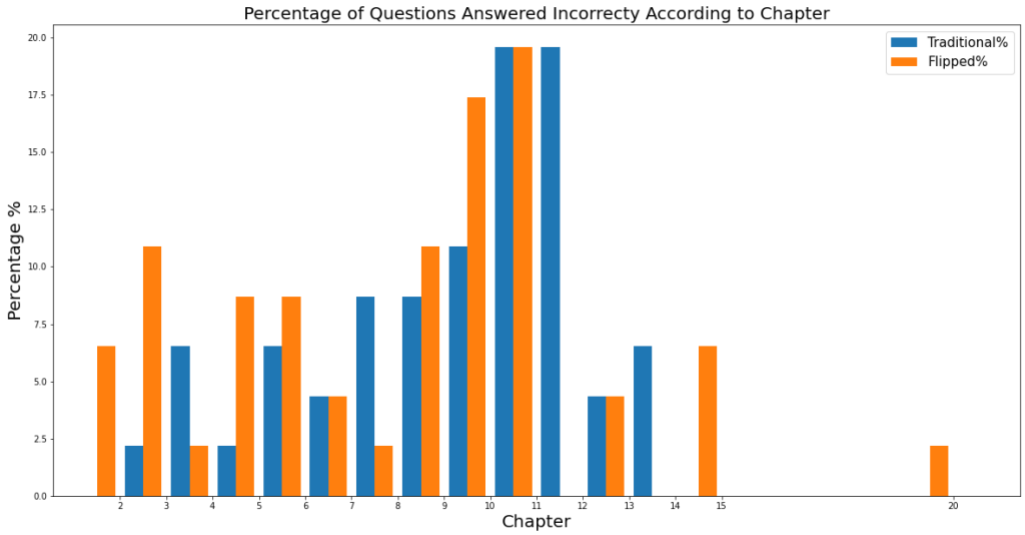

Figure 3 - Graph displaying the percentage of questions that students answered incorrectly according to chapter, the bars in front of each chapter number represent the data from that chapter.

Since the mean performance of the test scores comparing traditional and flipped classes did not differ significantly, further analysis was conducted. All the questions where more than 20% of the students answered incorrectly, assumed to be challenging questions, were categorized into three different question types: calculation, conceptual, and figure-based questions. Calculation questions involved solving numerical problems; an example calculation question includes "*What is the theoretical density of this material, given it is MgO? The ionic radius of Mg2+ is 0.072 nm and of O2- is 0.14 nm."* Conceptual questions were those which required understanding of theory. An example of a conceptual question is *"What is the driving force of carbon diffusion into steel during case hardening?"* Figure-based questions involved interpretation of figure followed by calculations or conceptual questions. An example of a figure-based question is *"Which phase(s) are present at point G and in what fractions?"* A figure would be included in this question in which students interpret and use to answer the question.

In the traditional class, there were three high stake exams which means a student's final grade in the class relied heavily on these exams. The percentage of each test in the traditional class contributed to 75% of total grade, 25% for each of the three exams. Figure 4 shows the percentage of incorrect questions according to type, split up by the three different exams from the traditional class. When observing the total percentage of questions wrong, Figure 4 shows that students struggled the least with Exam 1, the second least with Exam 2, and the most with Exam 3.

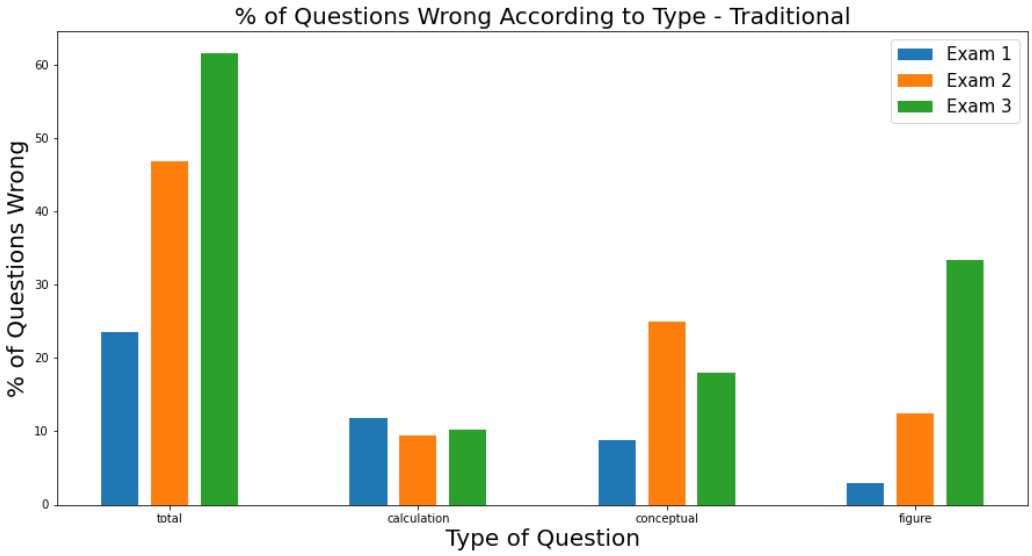

Figure 4 - Graph displaying the percentage of questions students in the traditional class answered incorrectly according to question type.

In the flipped class, there were five low stake exams which means a student's final grade was not as reliant on solely exams. The percentage of each test in the flipped class contributed to 40% of total grade, 8% for each of the five exams. Figure 5 shows the percentage of incorrect questions according to type, split up by the five different exams from the flipped class. In this analysis, students struggled the most with Exam 4 while the other exams were very comparable in difficulty.

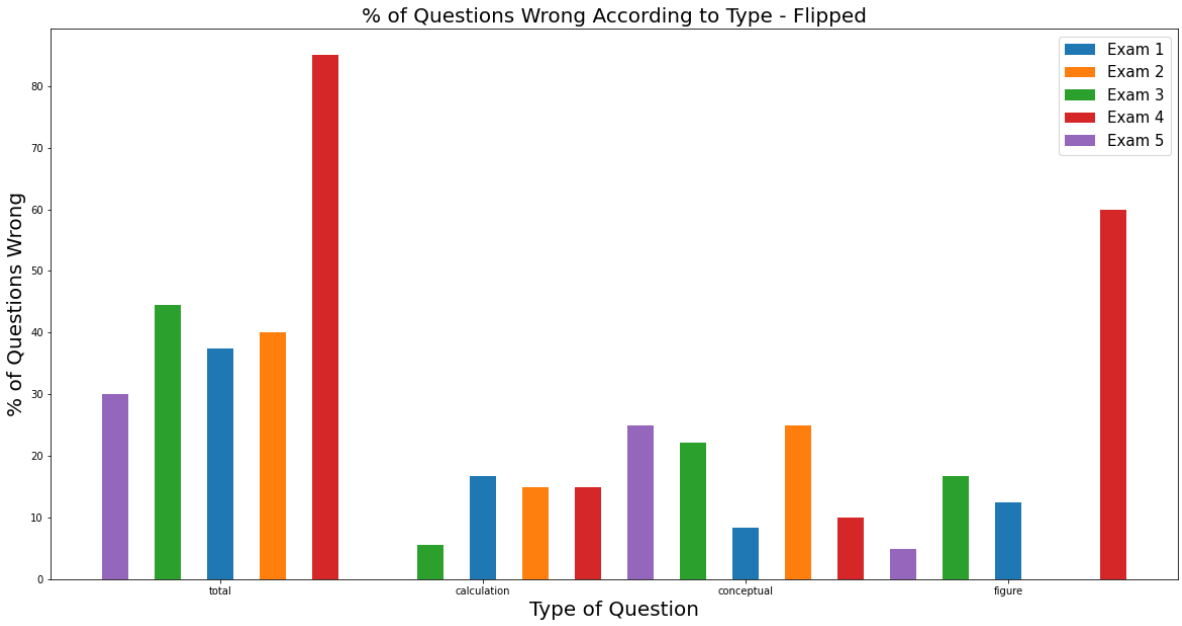

Figure 5 - Graph displaying the percentage of questions students in the flipped class answered incorrectly according to question type.

During data analysis, it was found that the total number of exam questions were similar when comparing traditional (105) and flipped (102) classes. Furthermore, the total number of questions that students answered incorrectly were also very comparable between traditional and flipped, which is shown in Figure 6. Following analysis of the comparison of question types answered incorrectly according to instructional strategy, a deeper analysis of total question types between traditional and flipped was conducted. It was observed that the total number of questions answered incorrectly between the traditional and flipped classes were almost identical. This supports the notion that an online environment makes the two teaching strategies equally efficient.

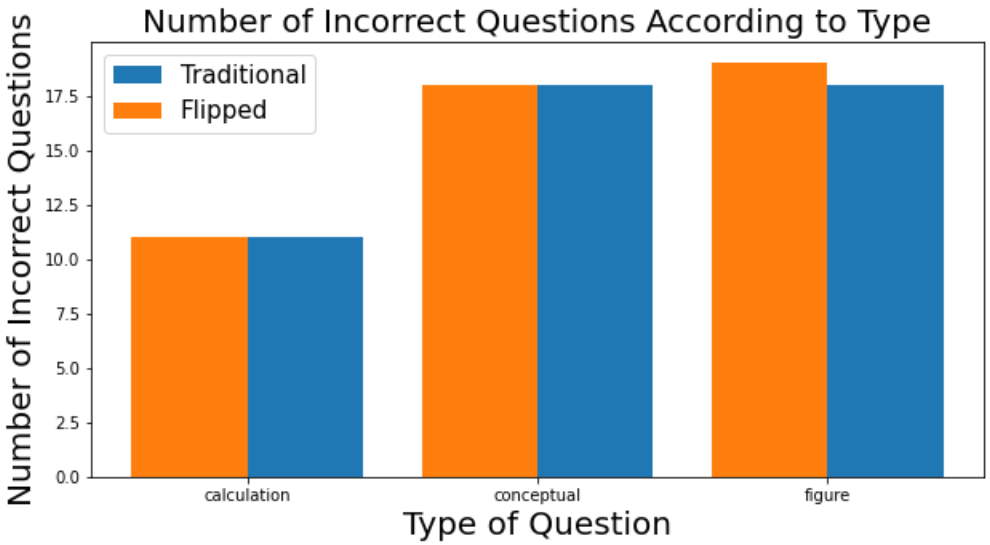

Figure 6 - Graph displaying the number of total questions wrong according to type.

b. Student Satisfaction

Figure 7 shows student response in the GatorEvals which pertain to the student satisfaction of the course and Table 1 shows the questions in the GatorEvals survey. Response ratings to questions relating to student satisfaction in the course evaluations were very consistent when comparing the flipped and traditional. However, the responses to the question asking about the online environment of the course contributing to the student's ability to learn the material (Question 11) was significantly lower than the rest in both flipped and traditional classes. In addition, the traditional class average response to the question pertaining to online environment was 2.7 while the flipped class average response was 3.1. This result supports the traditional class not being as satisfied with the online environment of the course compared to the flipped class. Overall, the fact that this question was rated noticeably lower than all the other questions implies that students do not think online classes can allow them to learn as well as they would in an in-person setting.

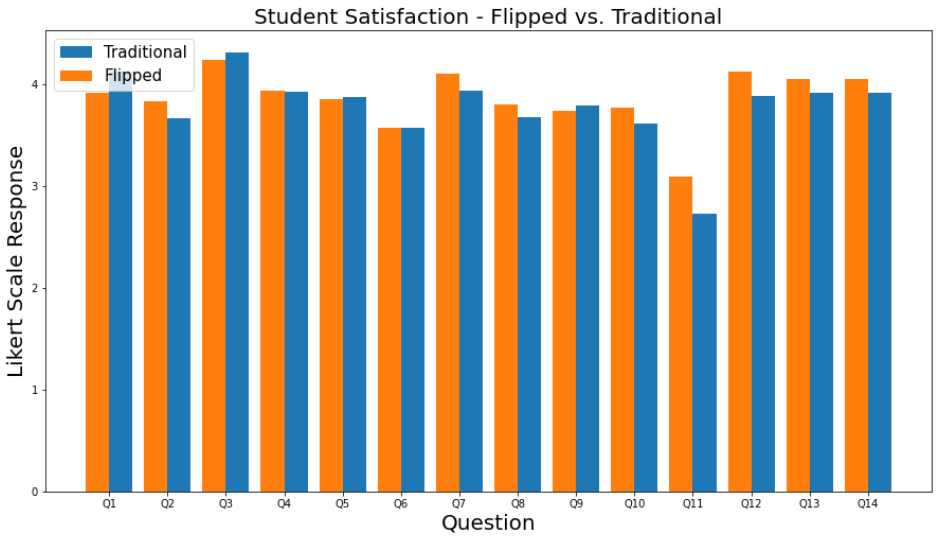

Figure 7 - Graph displaying questions from GatorEvals and Likert scale student responses.

#	Question
1	The instructor was enthusiastic about the course.
2	The instructor explained material clearly and in a way that enhanced my understanding.
3	The instructor maintained clear standards for response and availability (e.g. turnaround time for email, office hours, etc.)
4	The instructor fostered a positive learning environment that engaged students.
5	The instructor provided prompt and meaningful feedback on my work and performance in the course.
6	The instructor was instrumental to my learning in the course.
7	Course content (e.g., readings, activities, assignments) was relevant & useful.
8	The course fostered regular interaction between student and instructor.
9	Course activities and assignments improved my ability to analyze, solve problems, and/or think critically.
10	Overall, this course was a valuable educational experience.
11	The online environment of this course contributed to my ability to learn the material.
12	Student learning objectives were connected to course activities and assignments.
13	Course content is presented and structured in a logical, consistent, and organized manner.
14	There were a variety of assignments appropriate for an online course.

Table 1 - Table showing what was asked in each question regarding student satisfaction from GatorEvals.

This research aimed to investigate how teaching styles compare to one another when both delivered in an online setting and the quantitative results turned out to suggest that a certain style of teaching was not superior over the other. However, many studies do suggest that style of teaching does in fact significantly effect student performance and satisfaction. An interesting finding from the student satisfaction responses came from the responses to the survey inquiry saying, “The online environment of this course contributed to my ability to learn the material.” Students in the traditional class were more affected by the online environment when compared to the flipped class, however, the question as a whole was scored lower on the Likert scale compared to all the other questions from the GatorEvals.

Statistical analysis performed through JMP showed no statistical difference when comparing the average exam scores. However, the distribution patterns were different. A different distribution may represent a higher concentration of students performing better, worse, or average. For both the traditional and flipped class groups, test scores tended to be higher at first, followed by a

decline in performance. The trend is attributed to course content getting more difficult throughout the semester or many other extraneous circumstances. This suggests that a more effective course delivery can be achieved by integrating components from various instructional models. For example, a hybrid approach can be used, which can combine the positive elements from various models and can help in delivering the concepts with varying difficulty in different formats.

5. Summary and Conclusions

When it came to students learning the material, the traditional setup was better for some concepts while the flipped setup was better for others. One instructional strategy was not consistently better than another. There is a lot of support for these results to be different when evaluating these instructional strategies in an in-person setting [9],[10],[12]. In terms of student performance, the main metric involved student exam scores which were analyzed qualitatively and quantitatively by looking into the chapters the questions came from, the number of questions answered incorrectly, and the type of questions answered incorrectly. Student satisfaction was measured quantitatively by checking student feedback from the GatorEvals. It was determined that the online environment significantly influenced the student perspective when it came to learning the course material.

References

[1] Fatoni et al, "University students online learning system during Covid-19 pandemic: Advantages, constraints and solutions," *Systematic Reviews in Pharmacy;* 11(7):570-576, 2020.

[2] Hiranrithikorn, "Advantages and Disadvantages of Online Learning", *2019: INTERNATIONAL ACADEMIC MULTIDISCIPLINARY RESEARCH CONFERENCE IN BERLIN 2019;* 2019-10-31. http://icbtsproceeding.ssru.ac.th/index.php/ICBTSBERLIN2019/article/view/628

[3] A. Patricia Aguilera-Hermida, "College students' use and acceptance of emergency online learning due to COVID-19," *International Journal of Educational Research Open*, vol. 1, p. 100011, 2020, doi: 10.1016/j.ijedro.2020.100011.

[4] C. Weston and P. A. Cranton, "Selecting Instructional Strategies," *The Journal of Higher Education*, vol. 57, no. 3, p. 259, May 1986, doi: 10.2307/1981553.

[5] B. Dimitrios, S. Labros, K. Nikolaos, K. Maria, and K. Athanasios, "TRADITIONAL TEACHING METHODS VS. TEACHING THROUGH THE APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE ACCOUNTING FIELD: QUO VADIS?", *ESJ*, vol. 9, no. 28, Oct. 2013.

[6] K. V. Mattis, "Flipped Classroom Versus Traditional Textbook Instruction: Assessing Accuracy and Mental Effort at Different Levels of Mathematical Complexity," *Tech Know Learn*, vol. 20, no. 2, pp. 231–248, Jul. 2015, doi: 10.1007/s10758-014-9238-0.

[7] B. Kerr, "The flipped classroom in engineering education: A survey of the research," 2015 *International Conference on Interactive Collaborative Learning (ICL)*, Firenze, Italy, 2015, pp. 815-818, doi: 10.1109/ICL.2015.7318133.

[8] Brame, C. “Flipping the classroom.” *Vanderbilt University Center for Teaching*. 2013. Retrieved [11/20/2022] from http://cft.vanderbilt.edu/guides-sub-pages/flipping-the-classroom/.

[9] C. Gillette, M. Rudolph, C. Kimble, N. Rockich-Winston, L. Smith, and K. Broedel-Zaugg, “A Meta-Analysis of Outcomes Comparing Flipped Classroom and Lecture,” American Journal of Pharmaceutical Education.

[10] Z. Unal, A. Unal, “Comparison of Student Performance, Student Perception, and Teacher Satisfaction with Traditional versus Flipped Classroom Models,” INT J INSTRUCTION, vol. 10, no. 4, pp. 145–164, Oct. 2017, doi: 10.12973/iji.2017.1049a.

[11] Weerasinghe, Salinda & Lalitha, S & Fernando,. “Students' Satisfaction in Higher Education Literature Review”. *American Journal of Educational Research*. 2017, 5(5), 533-539. DOI: 10.12691/education-5-5-9

[12] E. Martínez-Caro and F. Campuzano-Bolarín, “Factors affecting students’ satisfaction in engineering disciplines: traditional vs. blended approaches,” *European Journal of Engineering Education*, vol. 36, no. 5, pp. 473–483, Oct. 2011, doi: 10.1080/03043797.2011.619647.

[13] P. A. Ertmer and T. J. Newby, “Behaviorism, Cognitivism, Constructivism: Comparing Critical Features From an Instructional Design Perspective,” *Perf. Improvement Qrtly*, vol. 26, no. 2, pp. 43–71, 2013, doi: 10.1002/piq.21143.

[14] Weegar, Mary Anne and Dina Pacis. “A Comparison of Two Theories of Learning -- Behaviorism and Constructivism as applied to Face-to-Face and On line Learning.” *E-Leader Manila 2012*. 2012.

[15] Bada & Olusegun, S. “Constructivism Learning Theory : A Paradigm for Teaching and Learning.” IOSR Journal of Research & Method in Education (IOSR-JRME) e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 5, Issue 6 Ver. I (Nov. - Dec. 2015), PP 66-70 www.iosrjournals.org