Evaluation of Flipped Mathematics Courses Knowledge Retention

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Abstract

A flipped learning approach has become more popular as technological advancements have reached into the educational sphere. This increasingly favored instructional format has key characteristics that allow increased interaction between professors and students. With the migration to this new pedagogy, instructors have notice increased performance within the course in comparison to a traditionally taught course. However, this case study aims to evaluate the knowledge retention in a flipped learning environment for a college level pre-calculus algebra and trigonometry courses using a simple survey design. Moreover, this study compared the flipped environment and a traditional learning format using course surveys for examining student success in advanced mathematics courses, primarily advanced Calculus courses.

1. Introduction

As in this study, lectures or notes, for a flipped classroom are often delivered by online videos specifically covering topics and concepts revolving around the content for the course. An article also noted these videos often have a question or comment embedded "to enhance students' learning of the information presented in the video [and] to assess students' understanding of what they are watching" (Lim & Wilson, 2018, p. 381). Flipped learning has become more popular as educational technology has advanced as well as the students' technological literacy. As defined by an article, "flipped learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter" (Flipped Learning Network, 2016). This allows instructors to present materials in captivating ways outside of the classroom to ensure flexible and more engaging comprehension for students. Altemueller and Lindquist (2017) reviewed flipped learning classrooms and stated that this methodology allows for student-driven learning, increased student motivation, and instant feedback for formative assessments.

Carter, Carter, and Foss (2018) evaluated the effect of flipping the classroom of a general education mathematics course for a diverse student population. The professors used a quasi-experimental design to compare seven different professors teaching a total of thirteen different sections of either flipped or traditional style learning. From this, Carter, Carter, and Foss (2018) found that not only did scores improve from pre-test to post-test, but scores also had the largest increase in the flipped learning courses. It worth noting that the racial achievement gap reduced significantly within the flipped learning courses in comparison to traditional style. Researchers wanted to continue to explore the difference in performance for liberal arts majors compared to STEM majors as the difference in scores was not statistically significant.

Research on flipped learning thus far at all levels has primarily focused on the comparison between assessment scores of the traditional teaching methodology and the flipped style. Chien and Chiang Hsieh (2018) studied students' achievement, motivation, and receptivity in a flipped learning classroom for half a semester and compared it to a

traditional style classroom in the other half of a semester. Students' achievement and motivation increased according to assessment scores; however, the receptivity of the students varied and often lower compared to a traditional classroom.

Wladis and Morgulis (2011) studied the success and retention of minority students in prerequisite mathematics courses for STEM disciplines. Focused on the teaching style of intermediate algebra, their study compared traditional teaching styles and student-centered discovery-based learning. Wladis and Morgulis (2011) found that post-test scores were significantly higher for students that participated in the collaborative learning, or flipped learning, and it also saw a larger increase in the pre-test to post-test scores. Students in the study were tracked in the subsequent semesters to observe the trends of flipped learning, which remained similar.

The purpose of this current study is to determine whether the results of the study could suggest future implementation of teaching styles at Fayetteville State University. We hypothesized that a flipped classroom utilizing online videos that incorporate an appropriate level of remediation, with motivation provided by regular in-class quizzes, and in-class collaborative problem solving would improve learning as measured by final exam scores, compared with traditional, lecture-based instruction, but it will not have the same level of knowledge retention to that of traditional learning style.

2. Problem Statement

The importance of understanding the effects of implementing a flipped learning style on students and the effects not only during the flipped learning style and all following mathematics courses. The prevalence of flipped learning has increased in recent years in the education industry. However, its implementation requires uniformity in structure but adaptability to each set of students for the most effective learning. Yet, even with research showing the performance of students is higher in flipped learning than it is in the traditional teaching structure, there is a question of students' ability to retain information from flipped learning classes. There is a need for a better understanding of the retention of flipped learning courses after their completion in comparison to traditional learning structures. More specifically, the study addressed following research questions:

1) How does student performance of advanced-level mathematics courses differ when grouped-by learning structures of pre-calculus courses?
2) What is the significance of learning outcomes and knowledge retention of students in flipped learning classes when compared to that of traditional learning structures for pre-calculus algebra and trigonometry courses?
3) What significant perceptions of the two pedagogies and how does that affect their learning within them?

3. Objectives

The long-term goal of the research is to develop a formal understanding of knowledge retention of the Fayetteville State University Department of Mathematics and Computer Science pre-calculus courses to better prepare students for advanced mathematics courses. The objective of the current study is to provide a comprehensive review of literature and teaching practices concerning and affecting mathematics knowledge retention. Particularly, the study had the following sub-objectives:

1) To provide a comprehensive review of sources and characteristics of the different pedagogy found at the university.
2) To review the quality of current teaching practices regarding student performance and knowledge retention.
   The result of this study will be valuable to those in academia to better understanding the effects of flipped learning on students throughout their academic careers as well as improve knowledge retention of students pursuing advanced mathematics courses.

4. Preliminary Literature Review

A preliminary literature review reveals that past studies primarily focused on the comparison of traditional-style learning and the flipped learning class structure. Most studies evaluated high schools' mathematics courses; however, the post-secondary studies did focus on the performance of all students in general education with the interpretation of variables including gender, race, and majors. Limited assessments have been made on the knowledge retention of the students in the subsequent semesters following the implementation of a flipped learning environment. What is missing from the past studies is a comprehensive report on the comparison between the flipped learning and the traditional style knowledge retention.

5. Methodology

The primary research method for this study is a literature review and the utilization of voluntary surveys. This study will first review grades of pre-calculus courses, both flipped and traditional style, and the grades of subsequent Calculus courses. Based on the initial data, surveys were distributed for qualitative information regarding the

impressions of flipped learning versus traditional learning. This allows for the ability to compare performance as well as perception between the two pedagogies at Fayetteville State University. Finally, a conceptual pedagogy will be identified as the preferred method for the university and presented as a recommendation to the department.

6. Results

This case study was conducted at Fayetteville State University, which typically hosts around 5,000 undergraduate students. This size of total university enrollment drives the number of available courses for each level of Calculus (I, II, and III) to be limited. The limited course offerings per semester created a small sample size of survey responses; thirteen responses from the total 94 students. The surveys were available to all qualifying students, but responses were voluntary. Students qualified for the survey if they had completed the prerequisite pre-calculus courses and were enrolled or completed advanced mathematics courses. Of the received responses, most students were enrolled in Calculus II at the time of the survey and the majority also had taken the prerequisite pre-calculus course, MATH 129 &130, in the traditional format. Only two students had taken pre-requisite course in the flipped format. This information can be seen further in Figure 1.

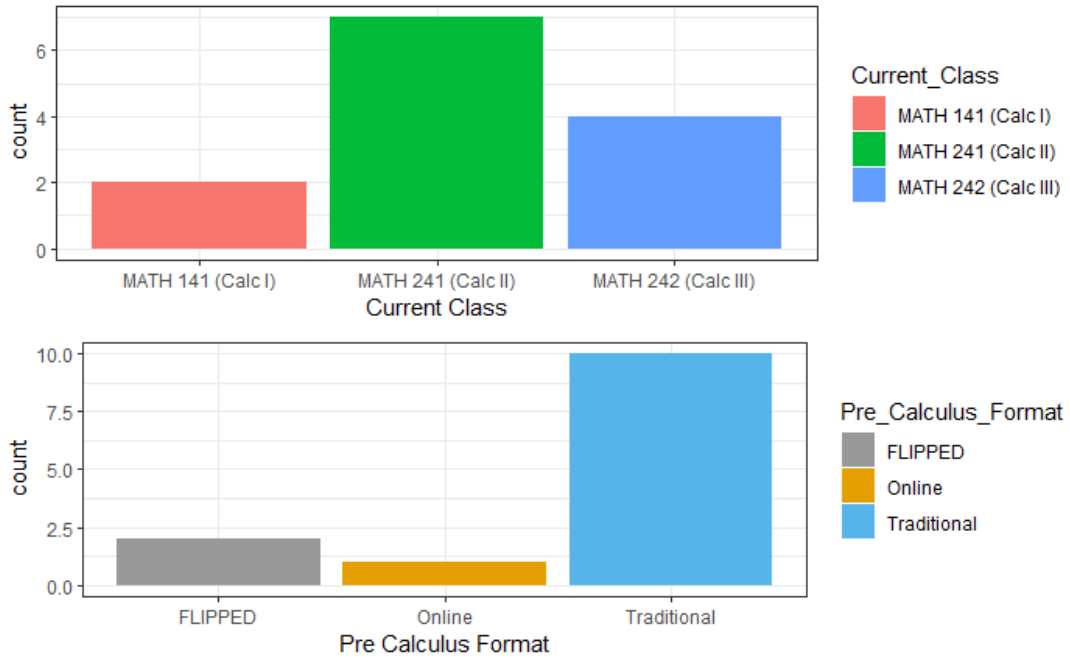

Figure 1: Breakdown of student information for those who responded to survey.

The survey results provided additional information about student performance in their advanced calculus courses as well as their feelings towards the flipped learning model specifically when used in teaching mathematics courses. All survey participants were encouraged to answer each question truthfully and to the best of their ability.

7. Analysis

Within the survey responses, grade distribution was acquired in terms of whether the student would or has passed the course with a 70% or higher. This was then broken down to evaluate if there is a noticeable difference between those who took the flipped prerequisite courses versus those who were taught in a traditional format. In Figure 2 we see this grade breakdown based on the different advanced mathematics course and pre-calculus course format.

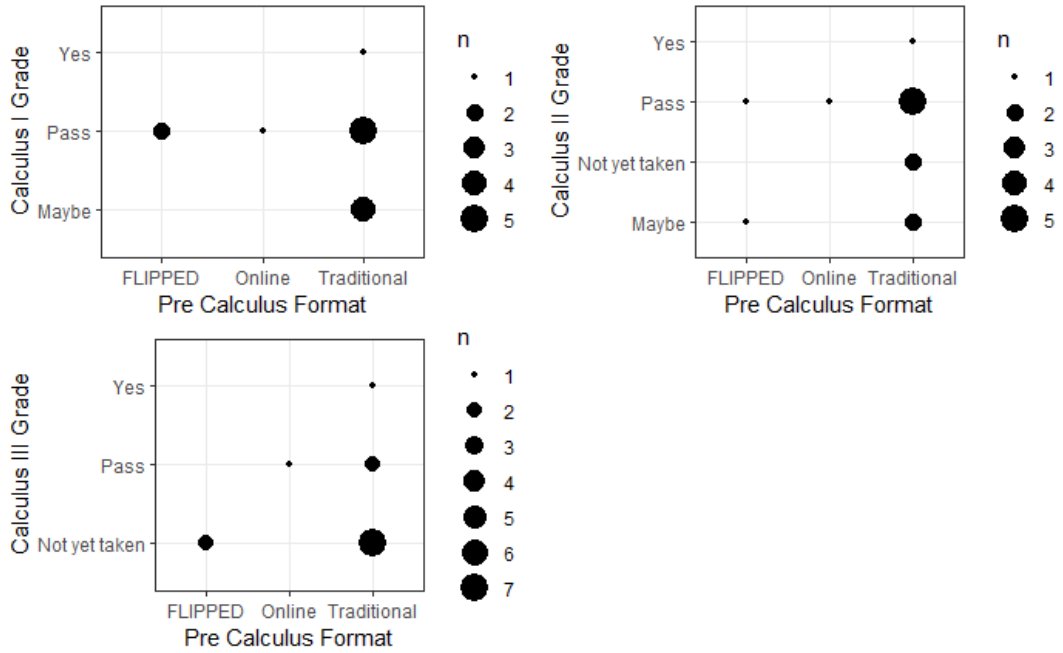

Figure 2: Grade Breakdown between different Calculus Courses based on MATH 129 &130 Format.

Due to the lack of conclusive evidence in the grade distribution to infer that one prerequisite mathematics format is superior to another further analysis is needed. When the survey respondents were asked if they felt that their pre-calculus format had any effect on their current learning abilities the majority said there was no effect, and a few noted that this course was several semesters ago and that they do not remember any specific effects. Similarly, when asked if the students had learned any skills from the format of the prerequisite math course the majority said that they had not. Because a major component of the flipped model is note taking, it is interesting that none of the students who took the prerequisite course in the flipped format mentioned note taking as a skill that they had learned or developed. By looking at student performance and skills developed, there is no statistically significant difference in the knowledge retention of students taking prerequisite mathematics courses in any format.

Looking at the perceptions and beliefs of students in mathematics have about the flipped learning model provides insights into students' motivations rather than performance. When asked about their overall opinions of flipped learning, the common responses mentioned that flipped learning put too much emphasis on taking notes a certain way and overall time consuming. Students hint that professors spend their efforts on conforming to the flipped model rather than working on numerous examples. In addition, students were asked if they would prefer their current Calculus course offered in the flipped format. The two-thirds of students who took their prerequisite math course in the traditional format said that they would not take their current course in the flipped format and those whose prerequisite math course was flipped had a split decision for their current Calculus course format. Figure 3 shows these results as well as if students find themselves having to relearn previous course material.

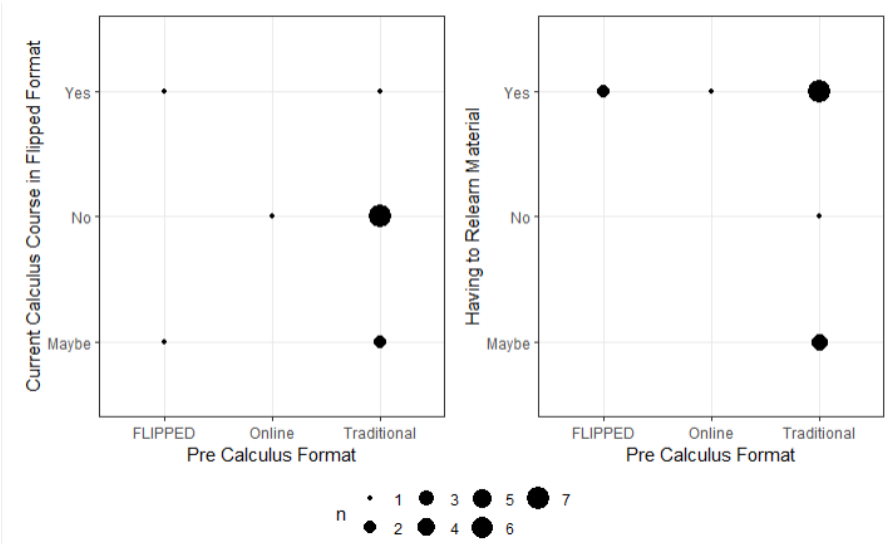

Figure 3: Student opinions on the flipped learning model.

Most students who participated in the survey found themselves having to relearn previous course material regardless of prerequisite course format. There were few students that noted that they did not have to relearn previous material. The results from the survey signal that the knowledge retention in the students is similar as both need to review previous material.

8. Conclusion

The case study results focused primarily on a student's long-term motivation, knowledge retention, and performance. With minor difference in the grades distributions and having to relearn previous course material based on different prerequisite mathematics courses, in this case study MATH 129 and 130, there is no conclusion that being enrolled in one format provides long-term benefits over another. The knowledge retention from the different pedagogies within the mathematics discipline are comparable. The keynote from the survey is the student motivation for the flipped learning model. The respondents recognized that often professors are more focused on following the flipped format at the expense of the material. This hints at when given the opportunity to enroll in a flipped mathematics course, students are unlikely to do so. Additionally, for better understanding further comprehensive research and analysis on the knowledge retention should be conducted.

With the unprecedented times that COVID-19 presented, this study was not able to be conducted as initially planned. If done as planned, starting in the pre-calculus courses, students pre-post-test scores would be compared for both a flipped and traditional format. Then these same students would be followed as they progress through Calculus I, II, and III where pre-post-test scores and qualitative information would be compared. However, with COVID-19 forcing courses to be taught safely online, flipped and traditional courses have not been implemented. This has caused data to be pulled from previous semesters before the Spring of 2020.

The study performed in this paper has shown that there is no difference in knowledge retention between flipped and traditionally taught pre-calculus courses, but advanced mathematics students have a negative perception towards a course taught in the flipped format.

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