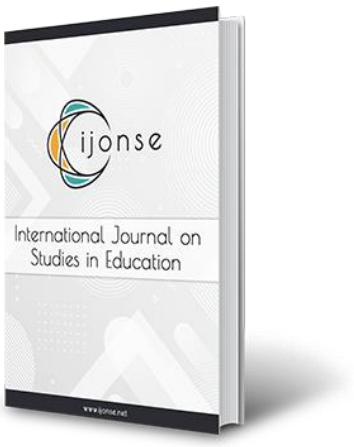

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Improving Success and Retention of Liberal Arts Students in a Large Math Class

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Abstract

The Mathematics for Liberal Arts course is designed for students outside of STEM fields who need to take a mathematics course for the general education requirement. Typically, students in this class are not math enthusiasts. In this study, I analyzed performance data of Liberal Arts students in the Fall 2017 and Spring 2018 at University of Central Florida. Based on data reports and analytics, the course content was revised, and activity learning strategies were implemented in the Fall 2018. Furthermore, early alerts and encouragements were sent during or just after topics identified as difficult were taught. Class activities were tailored to improve students' understanding. Homework, quizzes, and test scores were analyzed and compared with the two previous semesters. The results showed that the pedagogical methods implemented contributed to increase the overall passing rate and retention of students.

Introduction

According to Bonwell and Eison (1991, p. 2), active learning is any teaching approach that "involves students doing things and thinking about the things that they are doing." It is the opposite of the traditional approach, in which students passively receive information from an instructor. A vast body of literature has shown evidence of the benefits of incorporating active learning strategies into the classroom for undergraduate education (Miller & Schraeder, 2022; Baeten et al., 2010; Braxton, Jones, Hirschy, & Hartkey, 2008; Prince, 2004; Anderson & Adams, 1992; Johnson D., Johnson R., & Smith, 2014; Chickering & Gamson, 1987; McKeachie, Pintrich, Yi-Guang, & Smith, 1986). As a matter of fact, active learning in large classes is a well-debated topic in educational research (Burch & Mohammed, 2019; Benton & Pallett, 2013; Hasan, 2012; Xu, 2007; Allen & Tanner, 2005; Stanley & Porter, 2002; Carbone, 1998).

Teaching and motivating a large math class for Liberal Arts students are specific challenges that the mathematics faculty at University of Central Florida (UCF) have been working on. Explorations in Mathematics is a course designed for UCF students outside of STEM fields who need to take a mathematics course as a major requirement. Most students taking this course are non-science-oriented and not particularly interested in mathematics.

In this paper, I analyzed students' performance data on Exploration in Mathematics courses to identify their

struggles to improve their success and retention rates. Based on these data reports and analytics, I revised the course content and implemented the appropriate pedagogical strategies.

The remainder of this paper is organized as follows. Section 2 describes the original course structure and data analysis of the Fall 2017 and Spring 2018 courses. The third section presents the conceptual framework of the study, while the next section describes the changes implemented in Fall 2018, including the activity learning strategies and technologies used in the classroom. The results are presented in Section 5 and discussed in Section 6. The final section presents conclusions and further directions.

Course Structure and Analysis

Original Course Description

Explorations in Mathematics is a course offered at UCF for students who are not planning to take upper-level mathematics. It is a large class (with 150-350 students during the fall and spring terms), with three credit hours, and conducted face-to-face.

The course explores the beauty and utility of mathematics in the following sequence:

- Voting System
- Euler Circuits and Paths
- Hamilton Circuits and Paths
- Financial Mathematics
- Symmetry
- Fibonacci Numbers

For the fall and spring terms, all sections use the same syllabus and same assessments including online homework and quizzes posted on the MyLabsPlus (MLP) platform, three (paper-scantron) tests, and a comprehensive final exam. Each content is covered in three or four lectures. In addition, supplemental instruction (SI) sessions, guided by an SI leader, are available for students enrolled in this course who want to improve their understanding of the material and their grades. While the sections are coordinated, the instructor has the freedom to use evidence-based learning strategies to increase student engagement in lectures.

For Fall 2017 and Spring 2018, the instructor followed the syllabus course, used iClicker in the classroom to encourage student participation, held three office hours, and reviewed the sessions for each test. The following components were used in grading: Homework: 7%; Quizzes: 8%; Class activities: 10%; Tests (three tests): 55% (average of the two best tests); and Final exam: 20%. The lowest score on homework, quizzes, and class activities were dropped.

I analyzed the students' performance in homework, quizzes, and tests in the same instructor's class during the Fall 2017 and Spring 2018 terms. These helped the instructor identify the students' key struggle points and addressed them in Fall 2018.

Data Analysis

In Fall 2017, of the 149 students enrolled in the course, 129 (86%) accessed the MLP and completed the assignments. In Spring 2018, of the 245 students enrolled in the course, 201 (82%) accessed the MLP and completed the assignments.

For both terms, the lowest homework grade was in the Fibonacci Numbers content, with an average 64.60 for Fall 2017 and 61.40 for Spring 2018. The lowest quiz grades were in the Fibonacci Numbers and Financial Mathematics contents, with averages of 44.30 and 48.60 for Fall 2017 and 35.5, and 43.60 for Spring 2018, respectively. The chapter in which students struggled the most on the tests in both terms was Financial Mathematics, with an average of 58.56 for Fall 2017 and 57.7 for Spring 2018.

In Fall 2017, the students' overall performance showed that 86% of those who accessed MLP passed the course, while 71% of all enrolled students passed (final letter grade of A, B or C). Failure (final letter grade of D or F) and withdrawal (final letter grade of W) rates were 18% and 11%, respectively. In Spring 2018, the overall student performance showed that 77% of the students who accessed MLP passed the course, while 62% of all enrolled students passed. Failure and withdrawal rates were 23% and 15%, respectively. For students who did not access MLP, 10% failed, and 90% withdrew.

Based on these findings, the key points for us to address would be the following:

- The struggle contents for students in Financial Mathematics and Fibonacci Numbers.
- The high number of students who did not complete the assignments.
- The high rates of withdrawals.

Using these analytics, I piloted a short-term action plan for Fall 2018. I revised the course content and implemented pedagogical actions to improve students' knowledge retention and increase their motivation. New class activities were tailored to help them grasp the critical content better.

Conceptual Framework

Learning and Motivation

An effective teaching approach should motivate and actively engage students throughout the learning process to promote meaningful learning (Thompson & McDowell, 2019; Mill, 2000; Shihusa & Keraro, 2009; Nelson, 2000). Ausubel (1968) developed the theory of meaningful learning and related methods to facilitate classroom learning. According to Ausubel (1968), it occurs when learners find meaning in the presented information. Prior knowledge is crucial in this process which means that meaningful learning occurs when new knowledge is presented in such a way that learners can relate to previous knowledge or existing ideas. In this sense, introductory materials can be presented before new learning materials are presented in the classroom. This can help students connect new concepts with prior knowledge, processes, and reorganize information during instruction.

Motivation is an important factor in the learning process (Sprinthall N. & Sprinthall R., 1990; Hemke, 1990). According to Vygotsky (1962), it stimulates learners' needs, interests, and attitudes. Consequently, it is essential to determine achievement. Therefore, a motivated student is likely to be actively involved in the classroom and deeply engage in the material.

Encouragements and Interventions Messages

The instructors' actions in the classroom play a significant role in students' motivation and learning. However, it is also important for students to feel that instructors care about them as individuals and their progress. To this end, research has illustrated the positive impact of the instructor's praise on students' motivation (Burnett, 2001; Akin-Little et al., 2004). This allows instructors to selectively encourage different aspects of student production or output. For example, the instructor may use praises to boost students' performance, effort, accuracy, or speed on an assignment. According to Wong (2015), effective encouragement messages focus on the positive aspects of students' progress, attitudes, strategies, and efforts.

Another important factor that contributes to students' motivation is instructional intervention. According to Long and Siemens (2011), it is important to intervene when observing student behaviors, especially in the case of disengaged or at-risk students. Identifying students who do not submit or did poorly on assignments and grade average places them at risk of failing in the course. The instructor can send a message of support to the student, such as encouraging words and resources. Moreover, meetings can be scheduled with students to discuss possible strategies to achieve success. These interventions can be applied after the first week of class, tests, milestone assignment, or the week of the withdrawal deadline.

These actions provide valuable contribution to treating students as individuals rather than as a collective. By sending messages of encouragement and/or intervention, the instructor demonstrates a genuine interest in their success, displays a positive attitude, and supports at-risk students.

Cooperative Learning Groups

Cooperative learning group strategies have been increasingly used in higher education to improve student learning (Jainal & Shahrill, 2021; Brame & Biel, 2015; Davidson & Major, 2014; Johnson D., Johnson R., & Smith, 2014). Cooperation works to accomplish shared goals. In cooperative situations, individuals seek outcomes that are beneficial to themselves and all other group members.

In cooperative learning, students are instructed to work together in small groups to achieve a common goal (Aksoy & Doymuş, 2011, Johnson D., Johnson R., & Smith, 2006; Slavin, 1990, 1997). Working with peers has a positive impact on student engagement and learning (Benek & Bezir Akcay, 2019; Johnson D., Johnson R., & Smith, 2006).

Following the previous studies, the pedagogical strategies were implemented in a Mathematics for Liberal Arts class. The purpose of this study is to investigate the effect of the new approach on students' performance.

Methods

New Course Content Structure

The course contents were reorganized to allow more time for Financial Mathematics content, which is now covered by six lecturers instead of four. Moreover, the course coordinator and instructor put Symmetry and Fibonacci Numbers contents at the beginning of the semester to help students better grasp the content as early as possible. The course was taught in the following sequence: Voting System; Symmetry; Fibonacci Numbers; Euler Circuits and Paths; Hamilton Circuits and Paths; and Financial Mathematics.

Active Learning Strategy Implementation

As detailed below, the instructor addressed the struggle points by adding new teaching strategies in the classroom, sending both early alert warnings before teaching the contents that they most struggled with and interventions during or just after those contents were taught, and emphasizing the importance of consistency in assignment completion.

Student progress was monitored by the MLP platform, where the instructor could analyze the dashboard's customized early alert warnings and interventions to identify and target intervention for at-risk students. For example, students who did not work in the course for the period of time provided showed up on the inactivity card. Those who performed below the threshold provided on an assignment showed up within the associated assignment alert card, as well as those who missed a due date when applicable. As such, an intervention or encouragement message can be sent to students based on weekly alerts or inactivity data.

As pedagogical actions, before teaching the challenging content, the instructor sent encouraging messages to students, alert messages to those who did not start the assignments near the due date, and intervention messages to those who were struggling with the assignments, encouraging them to go to the instructor's office hours and/or SI session.

Example of messages sent to students during the semester are as follows:

- Encouragement: "We're about to enter more challenging content. Here are the resources to help you. If you have any questions or concerns, please stop during my office hours and/or go to the SI session."
- Inactivity: "I've noticed that you have been inactive for some days. It is just a friendly reminder that the "assignment" is due today at 11:59 p.m. Please do not leave for the last minute If you have any questions or concerns, please feel free to stop by my office hours (listed on the syllabus) or go to the SI session."
- Intervention: "I noticed that you have performed poorly on "test." If you have any questions or concerns, please feel free to stop by my office hours (listed on the syllabus) or go to the SI session."

In addition, the instructor emphasized the importance of consistency in assignment completion, not only in the classroom, but also via email. These factors can help instructors support at-risk students finish the course while there is still time to do so.

Following the Just-in-Time methodology (Novak et al., 1999), students are supposed to be prepared for class by reading the material posted on the WebCourses. Thus, the class started with a warm-up multiple-choice question for students to answer before receiving instruction on the topic. The instructor posed the questions using clickers. The students' answers allowed not only the instructor to focus on the points for which students needed more help but also the students to think about and pay more attention during the lecture.

Based on peer instruction strategy (Mazur, 1997), the lecture was divided into a series of brief presentations, each focusing on a central point. This was followed by a conceptual or practical question using a multiple-choice format, which explores students' understanding of the ideas presented. Students were encouraged to think through their answers for one to two minutes and report to the instructor using clickers. They were also asked to discuss their responses with their peers and try to convince each other about the correctness of their answers by explaining the underlying reasoning. The instructor polled the students again, discussed the correct answer, and moved on to the next topic. The use of clickers helps us take attendance, give real-time feedback, and set the stage for greater discussion by warm-up questions. Students were graded based on their answers to this assignment by participating (80% credit per lecture) and answering correctly (20% credit per lecture).

Table 1- Example of Class Activity for Voting Content

Class Activity 1 – Given the following theme park ranking, choose your closest preference order: Magic Kingdom – MK; Universal's Islands of Adventure – UIA; Bush Garden – BG.

# of voters	**A**	**B**	**C**	**D**	**E**	**F**
1st	MK	MK	UIA	UIA	BG	BG
2nd	UIA	BG	MK	BG	UIA	MK
3rd	BG	UIA	BG	MK	MK	UIA

Class Activity 2 – Based on the result of the preference schedule for the best park election, answer the following questions. If there is a tie, the winner will be the candidate with the fewest of last place votes.

# of voters	**25**	**23**	**29**	**31**	**21**	**19**
1st	MK	MK	UIA	UIA	BG	BG
2nd	UIA	BG	MK	BG	UIA	MK
3rd	BG	UIA	BG	MK	MK	UIA

a) Which theme park would win using plurality method?

b) Which theme park would win using the Borda count method?

c) Which theme park would win using plurality-w-elimination method?

d) Which theme park would win using the pairwise comparisons method?

Table 1 presents an example of an interactive clicker question for the voting method. In this activity, students were first asked to rank the theme parks in order of their preference using clickers. Based on the results, they needed to find a winning park using different methods. Finally, we compared the different winners of each method, if any.

Supported by the cooperative learning group strategy, the group assignments were incorporated into the classroom. Students were divided into groups of four, to whom the instructor assigned the same question, but with different methods to solve it, depending on the learning objectives of the content. The instructor encouraged the group to reflect on and discuss with their peers. Within these groups, students may be assigned specific tasks and then discuss their responses. During this process, the instructor and SI leader walked around the classroom, monitored the work, and helped and evaluated the group. After a certain amount of time, the groups shared their solutions with the class with a fruitful discussion. The activities were designed to motivate students to learn and master class content and collaborate. In addition, in some specific content, it stimulated students to understand that a solution to a problem can produce different answers when applying different methods. This is one of the learning objectives for most contents.

Table 2 shows an example of a group-work question for the Hamilton circuit. In this assignment, students were asked to find the shortest way to visit all cities using different algorithms. Finally, we discussed the shortest distance among all the algorithms.

Table 2 - Example of Group Assignment for Hamilton Circuit Content

A student wants to drive to five capital cities of the south-eastern of the United States in the shortest way possible. The student wants to minimize the distances between each of the cities. Figure below shows the distance between each of the capital cities. The tour must start and end at Tallahassee.

	Tallahassee-FL	Atlanta-GE	Columbia-NC	Montgomery-AL	Nashville-TN
Tallahassee-FL	*	272	355	210	490
Atlanta – GE	272	*	214	160	250
Columbia-NC	355	214	*	370	442
Montgomery-AL	210	160	370	*	282
Nashville-TN	490	250	442	282	*

a) Find the nearest-neighbor tour and give its total distance.

b) Find the repetitive nearest-neighbor tour and give its total distance.

c) Find the cheapest-link tour and give its total distance.

Overall, class activities accounted for 10% of the students' final grade. The main purpose of these activities is to motivate students' class participation, exploit collaboration among peers, and provide accurate feedback on

students' progress. Combining interactive learning activities and formative assessment, the instructor was able to access individual students learning needs, thus helping improve his/her attainment.

In addition, students gained an advantage in accessing the course materials, information, and instructor's lecturer slides which were posted on the WebCourse@UCF platform. The instructor also held three fixed office hours per week and attended students by appointment. Immediately after class, the instructor often attended students for an extra 20 minutes or so of discussions.

Results

In Fall 2018, of the 169 students enrolled in the course, 161 (95%) accessed MLP and completed the assignments until the end. As Figure 1 shows, the first homework challenge was the Fibonacci Numbers content. There was an improvement of scores in the Euler Circuit/Path and Financial Mathematics content. The first quiz challenge was symmetry, in which a stabilization of scores was observed. The lowest homework grade was for the Hamilton Circuit/Path content (with an average of 70.90), and the lowest quiz was for the Fibonacci number content (with an average of 51.30). The most difficult test content for students was the Hamilton Circuit/Path, with an average of 61.77.

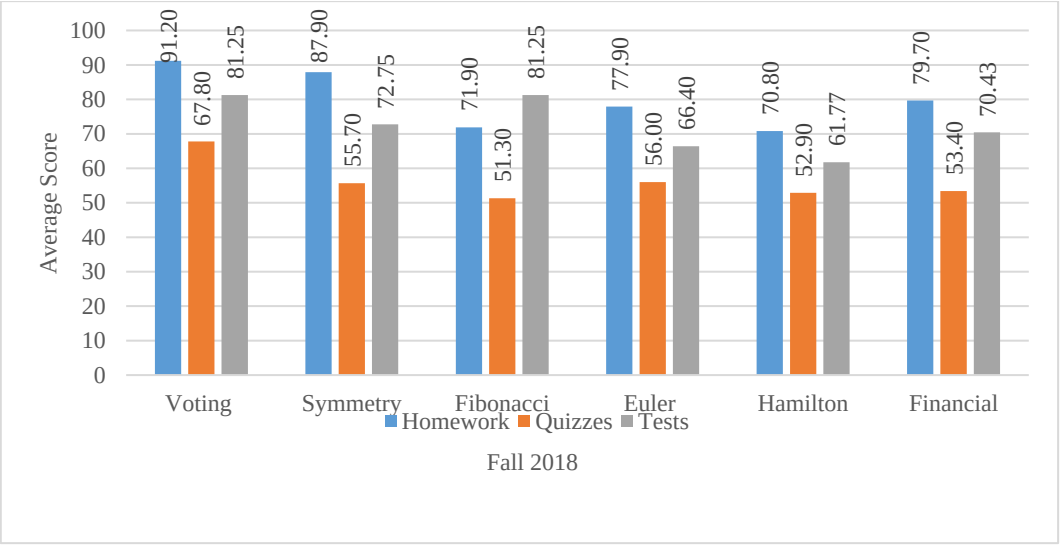

Figure 1. Average Score on Homework, Quizzes, and Tests for Fall 2018
(Homework and quizzes' data source: MLP platform).

Overall, 83% of the students who accessed MLP passed the course, and 100% of those who did not access it withdrew. The DF and W rates are 12% and 5%, respectively. Compared with previous terms, the Fall 2018 homework average of each content was more or less the same among the terms, with a slight improvement in the Symmetry and Fibonacci Numbers contents (see Figure 2). The quiz averages were higher for all contents; in particular, there was a 9.8% increase in financial mathematics when compared with Spring 2018, as shown in Figure 3. The quiz average had a statistically significant difference in mean scores when comparing Fall 2018 to both Fall 2017 ($p= 0.00053$) and Spring 2018 ($p= 0.00407$).

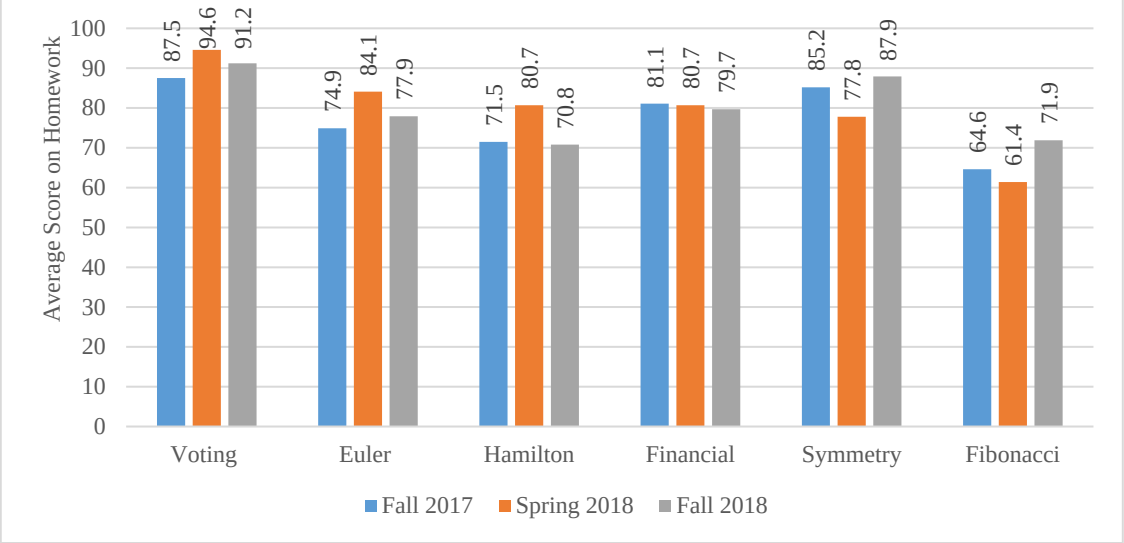

Figure 2. Average Score on Homework for Fall 2017, Spring 2018, and Fall 2018 (Data source: MLP platform).

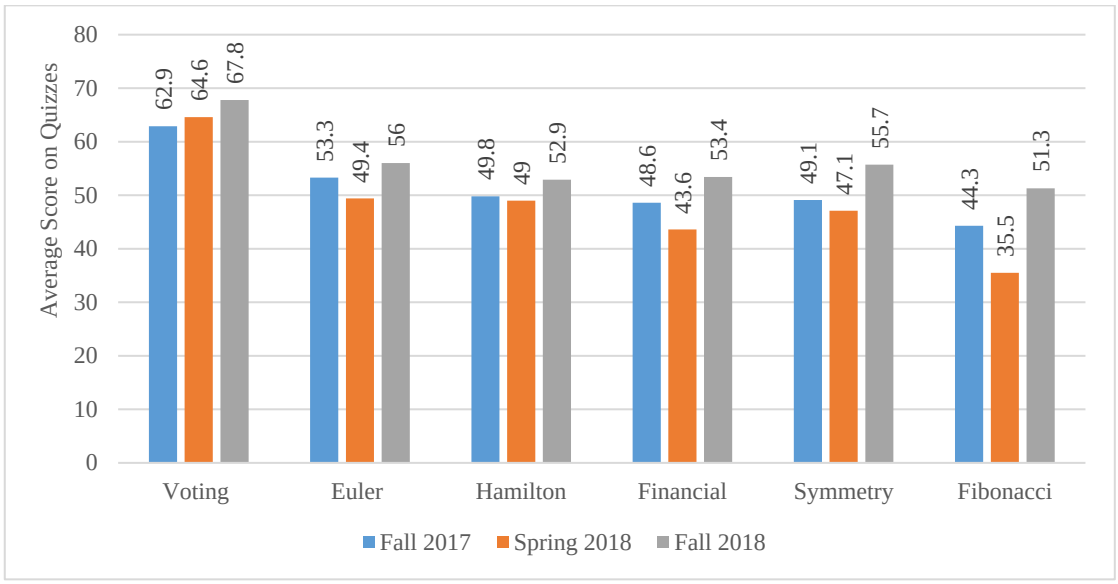

Figure 3. Average Score on Quiz for Fall 2017, Spring 2018, and Fall 2018 (Data Source: MLP platform).

Moreover, the Fall 2018 test averages also showed an improvement in all contents when compared with previous terms, especially in the voting system content, with an increase of 20.55% compared with Spring 2018 (see Figure 4). Overall, there was a significant increase in students' test scores ($p < 0.05$) when comparing Fall 2018 with both terms.

As shown in Figure 5, the number of students who accessed MLP increased, which means that students were more motivated to complete the assignments until the end of the course. Figure 6 shows that the overall passing rate substantially increased, while the withdrawal rates decreased. These results suggest that the pedagogical strategies implemented can offer students a successful conclusion.

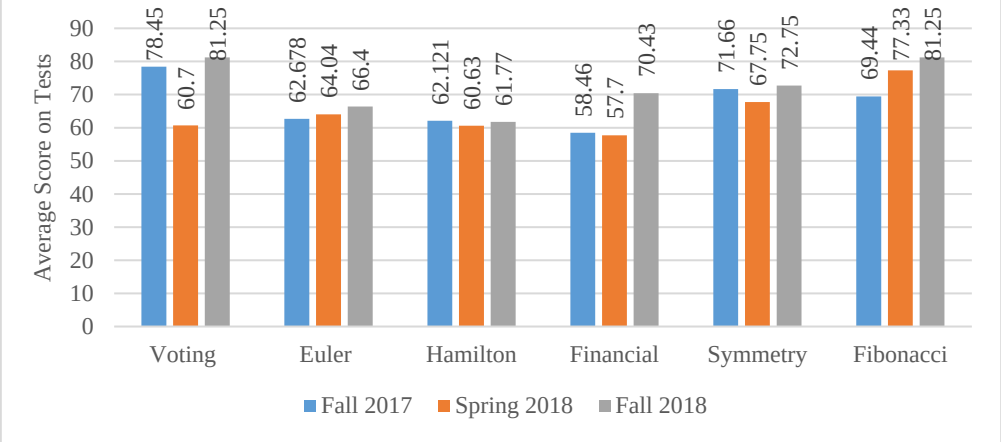

Figure 4. Average Score on Tests for Fall 2017, Spring 2018, and Fall 2018

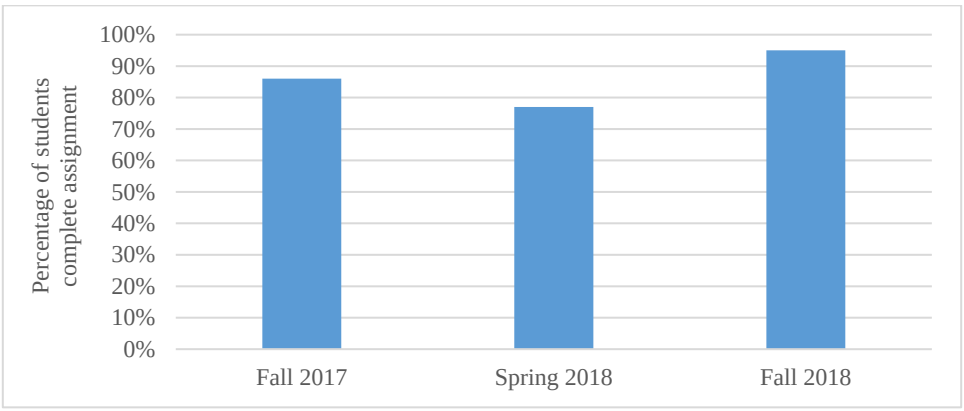

Figure 5. Percentage of Students who completed All Assignments until at the End of Each Term

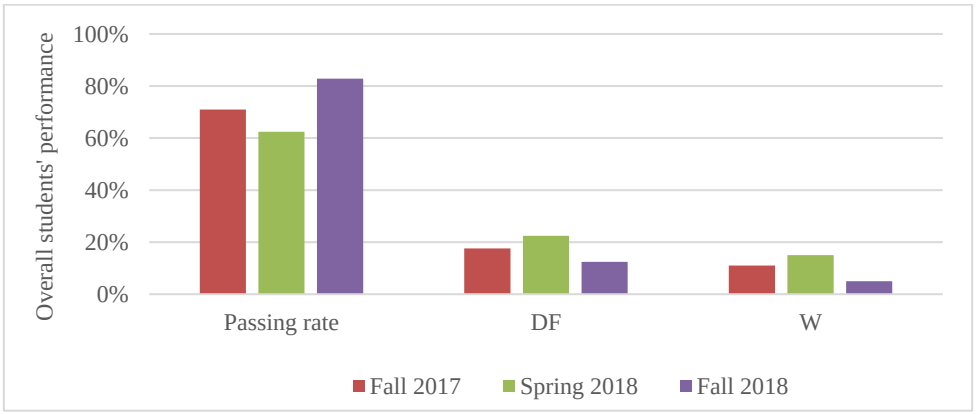

Figure 6. Percentage of Overall Students' Performance of Each Term

Discussion

The results of the study were promising and highlighted the benefits of using activity strategies in a large math class for Liberal Arts students. The data reports and analytics of previous terms provided an opportunity to work on the struggle points of the course for Fall 2018, such as the struggle contents for students, the high number of students who did not complete the assignments, and the high rates of withdrawal. Early alerts and

encouragements were sent during or just after the difficult topics were taught, and class activities were tailored to help students better grasp the content, particularly for the most difficult contents such as the Fibonacci Numbers and Financial Mathematics. Additionally, more time was invested in covering Financial Mathematics. For example, the instructor sent the following message of encouragement to students before starting the contents: "We're about to enter more challenging content. Here are the resources to help you. If you have any questions or concerns, please stop during my office hours and/or go to the SI session."

During the lecture, the instructor emphasized the importance of real-world content by presenting examples. For the application of these formulas, the instructor used clickers and group assignments. Table 3 shows an example of a class activity for Fibonacci numbers to learn how to interpret the formula.

Table 3. Example of Class Activity for Fibonacci Numbers Content

Express $F_{N+3} + F_{N+4}$ as a single Fibonacci number.
$F_{N+3} + F_{N+4} = F_{N+2}$
$F_{N+3} + F_{N+4} = F_{N+5}$
$F_{N+3} + F_{N+4} = F_{N+7}$
$F_{N+3} + F_{N+4} = F_{N+1}$

To emphasize the financial calculations, the instructor presented real applications as much as possible. Table 4 shows a group work problem in which students would need to interpret the data by comparing different percentages. This problem was presented at the end of the course to motivate students to know how to calculate their own course grades. Finally, the options were compared.

Table 4. Example of Group Assignment for Percentage Content

The student's grade average will be calculated using the following options:

	Option A	Option B	Option C
Homework	7%	7%	7%
Quiz	8%	8%	8%
Class Activities	10%	10%	10%
Test 1	20%	Average of the Best two test scores 55% (lowest or missed test score is dropped)	25%
Test 2	20%		25%
Test 3	20%		25%
Final Project	15%	20%	Project is not required.

Suppose you have scored:

- Class activity: 60 out of 100
- Homework: 78 out of 100
- Quiz: 53 out of 100
- Test 1: 50 out of 100
- Test 3: 80 out of 100

Based on your scores, which option would you get a higher final score?

The results revealed that the Fall 2018 students performed as well or better for Fibonacci Numbers, and better for Financial Mathematics than previous terms in terms of homework, quizzes, and test questions. Even though the efforts were more concentrated in those two contents, interestingly, all 2018 students performed better on quizzes and test questions compared with previous terms in all contents. In addition to mastery of skills and knowledge, the teaching method also had positive outcomes in terms of motivation, social interactions, and retention. For example, how well did they complete the course? Indeed, the most significant impact was on the number of students who completed the assignments until the end, and the overall passing and withdrawal rates. These findings align with recently studies showing that activities implemented had a positive effect on students' motivation, engagement, and achievements (Benek & Bezir Akcay, 2019; Thompson & McDowell, 2019; Jainal & Shahrill, 2021; Herpratiwi & Tohir, 2022).

The sample was limited to classes taught by the same instructor, which limits the generalizability of this study. However, my goal was to explore possibilities to increase successful course completion, retention, and motivation in a math class for Liberal Arts students without affecting the quality of the course content. Furthermore, this pilot will be revised, re-implemented, and analyzed.

Conclusion

An active teaching strategy was implemented in a large math class for Liberal Arts students. In Fall 2018, based on the data reports from previous terms, the course content was revised, early alerts and encouragements were sent during or just after the difficult topics were taught, and class activities were tailored to help students better grasp the content. The results of the Fall 2018 course were encouraging: students demonstrated equal or better homework, quizzes, and test performance than previous terms. With approximately 169 students in the course, the number of students who accessed MLP (95%) and the overall passing rate (83%) have substantially increased, and the withdrawal rates (5%) have considerably decreased. The results suggest that the pedagogical strategies implemented may play a key role not only in motivating and retaining Liberal Arts students in math courses, but also in offering students a successful course conclusion. In a forthcoming work, the goals are to combine adaptive learning, active learning, and open educational resources, and to build the course in a mixed-mode format, that is, taught face-to-face and online.

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