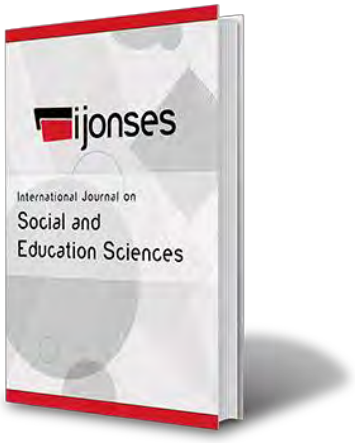


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**Nehal J. Shukla**
Columbus State University, United States

**Elizabeth Mcinnis**
Columbus State University, United States

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# Flipped Classroom: Success with First Year Mathematics Students

**Nehal J. Shukla, Elizabeth Mcinnis**

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## Abstract

In the modern era of internet and social media, teachers are pursuing new methods to integrate online resources and techniques into their curriculum and flipped classroom instruction model has been their response to this heightened digital migration. Despite this high amount of interest, few studies have evaluated the effectiveness of classroom flipping in mathematics on student academic outcomes. Specifically, no rigorous studies of the effects of flipping a mathematics course on students‟ mathematical understandings, course satisfaction and student‟s success appear in the literature. This study aims to understand the effectiveness of flipped classroom in first year undergraduate mathematics students at university level by measuring student‟s success via (1) students‟ overall course satisfaction (2) students‟ pre and post-test grade and (3) student‟s pass rate. Our study showed improved student‟s perception of course satisfaction and improved final grades (post-test compared to pre-test). We noticed some improvement in pass rate of flipped classroom students compared to non-flipped classroom students, but it was not statistically significant. We recommend future studies to see if this student‟s success transforms into improvement in student‟s attrition, retention, progression and graduation rate.

## Introduction

Challenged by the modern era of internet and social media, teachers are pursuing new methods to integrate online resources and techniques into their curriculum. A response to this heightened digital migration has been the flipped classroom instruction model. Flipping has garnered a large amount of hype from the popular education media and has been adopted in a variety of contexts. The seeds of this change were planted as early as 1993, when Alison King‟s paper (King, 1993)advocated a change in the teaching instruction from the teacher as the “sage on the stage” to be the “guide on the side.”

Flipped classroom as a model requires students to take charge of their learning and decisions during pre-class, in-class, and post-class (Prust et al., 2015)The knowledge obtained from each phase is used to promote students‟ reflection and communication throughout the learning process. Students in the „pre-class‟ phase are expected to engage with the learning materials provided by the instructor to obtain the necessary exposure for the „in class‟ phase, where they are provided with a set of learning activities such as discussion and group presentation with minimal support from the instructor. Then, in the „post-class‟ phase, students are exposed to different assignments or quizzes as an enrichment activity for strengthening their knowledge gained from the previous

phases. Several previous studies have validated the potential of learning through different phases in flipped classroom (Gong et al., 2018; McLean & Attardi, 2018). Flipped classroom typically uses technology to support learning and teaching (Lemmer, 2013), putting students at the center of developing knowledge (García-Peñalvo et al., 2016), (Wasserman et al., 2017), using real world problems to guide learning(Choi, 2013), and following an active and hands on approach (McNally et al., 2017). According to many experts (Enfield, 2016; Wasserman et al., 2017), flipped classroom education shifts passive learning to pre-class phases and emphasizes active learning during in-class phases. Research conducted by Gleason (Gleason et al., 2011) shows that using active-learning strategies can stimulate higher-order thinking, problem solving, and critical analysis, which are all desirable learning outcomes.

Despite global increased interest in flipped classroom, especially in the STEM (Science, technology, engineering, and mathematics) fields, the long-term effects of this method are yet to be tested (Lesseig & Krouss, 2017). While STEM program continue to suffer from low enrollments and high attrition (Petrillo, 2016), high failure rates in mathematical courses have haunted students, teachers, and administrators for decades. Factors contributing to high failure rates are that courses‟ content may be unavoidably difficult, the learning environment itself may be affecting student‟s interest and motivation, and financial factors where students are not able to afford high cost of the book for the course. Whether success or failure in the first-year mathematics and science courses is indicative of student potential in STEM, many students tend to abandon STEM major before they can even realize their potentials (Robinson, 2003)(Whalen et al., 2010). One way in which some mathematics teachers are attempting to meet modern educational challenges in STEM is by flipping their classroom(Bergmann & Sams, 2014; Crouch & Mazur, 2001; Jungić et al., 2015; Lage et al., 2000; Love et al., 2014). Flipped classroom claims to be advantageous due to many reasons. For instance, it allows more peer to peer instructions, and it increases student engagement. Increased engagement helps students develop positive attitudes about the material (Herreid & Schiller, 2013). Instructors work more closely with students which allows for more immediate and better feedback (Bishop & Verleger, 2013; Naccarato & Karakok, 2015). Published evidence suggests that the flipped classroom can have a positive impact on learning outcomes, student motivation and interest, and overall success in the STEM disciplines (Deslauriers et al., 2011; Moravec et al., 2010; Smith et al., 2011).

Assigning lectures outside of the classroom not only enables teachers to utilize class time to instruct using a variety of hands-on activities, but it also reduces the cost to students while increasing retention. Despite this high amount of interest, few studies have evaluated the effectiveness of classroom flipping in mathematics on student academic outcomes. Specifically, no rigorous studies of the effects of flipping an introductory mathematics course (Quantitative Skills and Reasoning) at undergraduate level on students‟ mathematical understandings, course satisfaction and student‟s success appear in the literature. The challenges of mathematics department at our university are no different than the rest of the world. As part of the QEP (Quality Enhancement Program), we strive to improve our attrition, retention, performance and graduation rate. As several of the above studies showed that flipped classroom model helps in improve student‟s course satisfaction, performance, attrition, and retention rate, two of our faculty {Faculty S and Faculty M} began envisioning a classroom to which students brought the basic knowledge of the day‟s lesson, a classroom in which students

were ready and able to talk and work with each other, and a classroom in which teachers are able to have the time and opportunity to reach out to every student. Faculties flipped their developmental 1000 level mathematics course of Quantitative Skill and Reasoning from fall 2018 to fall 2019. Both faculties had taught the same course in a traditional lecture-based model (non-flipped format) in previous years. The purpose of this study is three-fold and aimed to evaluate the effectiveness of flipped classroom using (1) students‟ overall course satisfaction (2) students‟ pre and post-test grade (3) student‟s pass rate.

## Methods

From fall 2018 through fall 2019, two faculties taught multiple sections of the developmental 1000-level mathematics course Quantitative Skills and Reasoning using a flipped format. Both faculties had previously taught this course in a non-flipped format. As we know that communication is of utmost importance when engaging students in an unfamiliar learning environment, therefore we were sure to outline the process carefully in our syllabi. Students were pointed to the many advantages of the flipped format and were made aware of the possible challenges involved. In particular, their increased responsibility was highlighted. We were also careful to ensure that students met the necessary technological requirements for success in the course – access to reliable internet and a computer. While we were sure to make our syllabi available for students prior to the start of the term, we did experience some flux in our rosters at the beginning of each semester due to students not being able or willing to commit to this learning environment.

In our non-flipped classrooms, a majority of class time was spent on lecturing the material and showing examples. We regularly engaged students in the process of working on examples in groups and individually to support lecture material. In our flipped classrooms, we used a standard set-up in which students prepared for class by watching lecture videos then came to class to synthesize that material through examples and real-world problem solving. Students engaged in more passive learning while outside of class, however they were also required to take brief pre- and post- quizzes during this phase in order to gauge learning.

After spending the first class-period expounding on the features of the flipped classroom and engaging students in an activity in which they research the pros and cons of this learning method, the second class-period was spent with students completing a Pre-Final to assess the knowledge they brought to the course. We graded this test but did not return them to the students; the test was re-administered at the end of the semester as the Final Exam. Faculty M did not give a Pre-Final in her fall 2018 classes and started giving Pre-Finals from fall 2019.

We carefully constructed our course design and timeline so that students followed the same process for each section covered in the course:

- Pre-Quiz (administered through our University‟s Learning Management System (LMS) – for research purposes only)
- Video Lecture (accessible only after the Pre-Quiz has been completed, also via LMS) and lecture presentation file for note taking purposes
- Brief in-class discussion of material (roughly 10 minutes) and questions from videos
- In-class activities, group exercises

- Post-Quiz (administered through LMS) evaluating student understanding of the material – available only after class activities for the sections that are completed.

Figure 1 shows flipped classroom course design as we discussed. This process was carefully designed before the start of the semester and required extensive planning on our part to ensure that the timing would be appropriate for each section. Note that the Pre- and Post-Quizzes were both relatively short assessments, and this out-of-class work took the place of more traditional "homework" assignments.

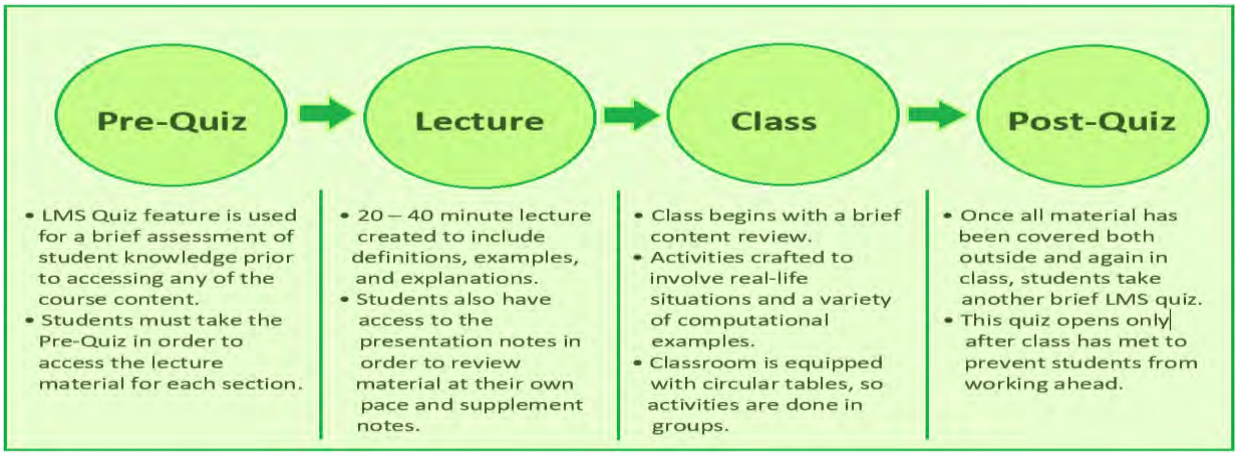


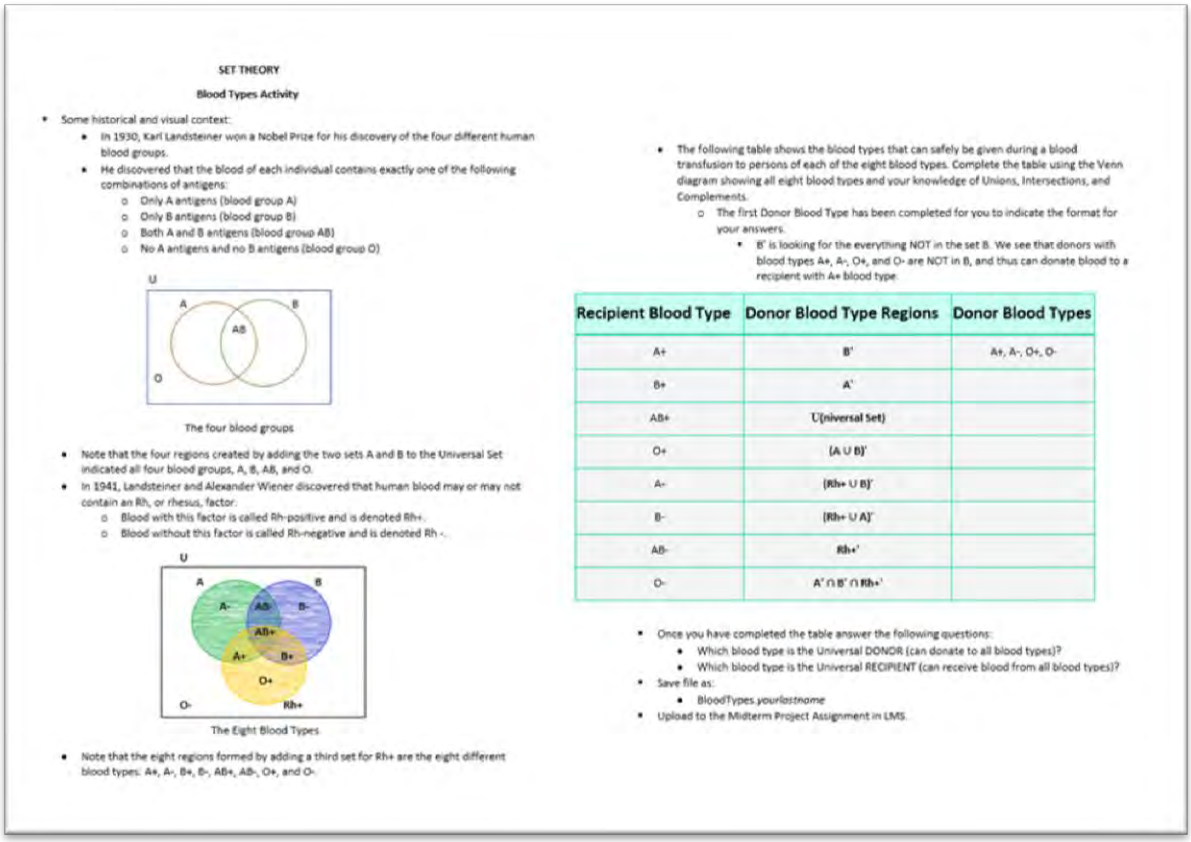

Figure 1. Flipped Classroom Course Design

In general, college freshmen are usually experientially aware of the flipped classroom format through high school English courses – reading literature before class then engaging in discussion during class-time. As our student population is typically unprepared for synthesizing mathematical knowledge through readings (particularly at this early level), we provided video lectures for our students to watch while preparing for class. It should be noted that student feedback was strongly in favor of multiple, shorter videos (less than 20 minutes). Longer videos were met with some resistance (see Survey Results).

For each section, we began our in-class time with a brief discussion of main content points, including examples where appropriate. We followed up by giving students an opportunity to voice questions that came up for them while watching the lecture videos. This is an essential step that follows up on possible confusion involved in "learning" the material via video lecture. It is challenging for both lecturer and student to connect over the ideas while working through it asynchronously. We found that it did not require in-depth review in order to clarify main points in person, and was well worth the small investment of class-time.

Following this discussion, class-time involved a variety of group problem solving activities that supported the content, and often expanded it to illustrate real-life applications. We are lucky to teach at an institution with a classroom space that encourages group work, with round tables each supplied with a portable rolling white board. Students were randomly assigned to groups of four, and new groups were generated in each class period, so students had opportunities to interact with all of their classmates several times across the semester. The activities were chosen by the faculty to ensure the pertinent topics and different techniques covered in a section

were included. An exercise might also be chosen specifically to spur a discussion amongst students. Students worked together to complete application problems and guided each other through examples and exercises. We, as a faculty, walked the classroom making suggestions and clarifying misconceptions and confusions. Figure 2 shows one of the examples of real-world problems that we used for classroom activity.



SET THEORY

Blood Types Activity

- Some historical and visual context:
  - In 1930, Karl Landsteiner won a Nobel Prize for his discovery of the four different human blood groups.
  - He discovered that the blood of each individual contains exactly one of the following combinations of antigens:
    - Only A antigens (blood group A)
    - Only B antigens (blood group B)
    - Both A and B antigens (blood group AB)
    - No A antigens and no B antigens (blood group O)



The four blood groups

- Note that the four regions created by adding the two sets A and B to the Universal Set indicated all four blood groups, A, B, AB, and O.
- In 1941, Landsteiner and Alexander Wiener discovered that human blood may or may not contain an Rh, or rhesus, factor:
  - Blood with this factor is called Rh-positive and is denoted Rh+.
  - Blood without this factor is called Rh-negative and is denoted Rh -.



The Eight Blood Types

- Note that the eight regions formed by adding a third set for Rh+ are the eight different blood types: A+, A-, B+, B-, AB+, AB-, O+, and O-.

- The following table shows the blood types that can safely be given during a blood transfusion to persons of each of the eight blood types. Complete the table using the Venn diagram showing all eight blood types and your knowledge of Unions, Intersections, and Complements.
  - The first Donor Blood Type has been completed for you to indicate the format for your answers.
    - B' is looking for the everything NOT in the set B. We see that donors with blood types A+, A-, O+, and O- are NOT in B, and thus can donate blood to a recipient with A+ blood type.

| Recipient Blood Type | Donor Blood Type Regions | Donor Blood Types |
|---|---|---|
| A+ | B' | A+, A-, O+, O- |
| B+ | A' | |
| AB+ | U(niversal Set) | |
| O+ | (A ∪ B)' | |
| A- | (Rh+ ∪ B)' | |
| B- | (Rh+ ∪ A)' | |
| AB- | Rh+' | |
| O- | A' ∩ B' ∩ Rh+' | |

- Once you have completed the table answer the following questions:
  - Which blood type is the Universal DONOR (can donate to all blood types)?
  - Which blood type is the Universal RECIPIENT (can receive blood from all blood types)?
- Save file as:
  - BloodTypes.*yourlastname*
- Upload to the Midterm Project Assignment in LMS.

Figure 2. Example of Classroom Activity

Sometimes, it was not possible to complete activities within one class period. In these instances, we made an effort to draw some conclusions before the end of the in-person time and point toward next steps for the following class. Once again, time management is essential to making this endeavor successful. Effectiveness of the flipped classroom was evaluated via students‟ overall course satisfaction, pre and post final grades and pass rate of flipped classroom students which was compared with students of non-flipped classroom.

**Student's Overall Course Satisfaction**

Questionnaire was given to students of both the instructors (S and M) from fall 2018 to fall 2019 (n=157). Student‟s overall course satisfaction was measured by their answers to following one to five questions:

1) Whether they watched video on time before going to the class?
2) If they found brief classroom discussion at the beginning of each section helpful?
3) How confident they were about the teaching material after watching video but before coming to the classroom?

4) How confident they were about the teaching material after watching video and after coming to the classroom to participate in classroom discussion and activities?
5) Did they find pre and post quizzes for each section helpful?

Two open ended questions (6 & 7) were also included in the questionnaire; answers to them were thematic responses.

*Student's Pre and Post-Test Grade*

Each student (n=157) in the flipped classroom for both instructors from fall 2018 to fall 2019 were given pre-test on the second day of the class to measure knowledge that they brought to the class. These tests were graded but were not given back to students. The same test was given to all the students at the end of their semester as the final test (posttest). Effectiveness of flipping and learning was measured by their grade difference.

*Pass Rate*

Both the faculties taught students in the 1000-level mathematics course Quantitative Skills and Reasoning using non-flipped format (traditional method) in the previous year. We have compared the pass rate of the students of the non -flipped classroom with the pass rate of students with flipped classroom.

## Results

### Questionnaire

Toward the end of the semester, the following survey questionnaire (Flipped Classroom Student Survey Questions) was administered to all the students (n=157) of both the instructors (Instructor S and Instructor M) from fall 2018 to fall 2019; in an in-class, anonymous manner. Responses were recorded and aggregated for three semesters of Quantitative Skills and Reasoning .

It is clear that not all students were prepared to take on the extra responsibility and/or manage their time well enough to make sure that they followed the prescribed process of watching the lecture videos prior to class time. The majority of students answered positively on this question, (96%) but a response rate of 23% for "Some of the time" is still concerning (see Table 1).

Table 1. Did You Watch the Lecture Videos on Time?

| Response | Rate |
|---|---|
| Always | 30% |
| Most of the time | 43% |
| Some of the time | 23% |
| Never | 4% |

These results confirmed our sense that the initial, brief in-class discussion of the material was an important part of the process. Students needed that time to synthesize the material they were presented with in the videos while having the ability to ask questions and learn from others‟ questions. Brief in-class discussion was helpful per 99% students (see Table 2).

Table 2. Did You Find the Brief in-class Discussion at the Beginning of Each Section Helpful?

| **Response** | **Rate** |
|---|---|
| Always | 73% |
| Most of the time | 26% |
| Some of the time | 0% |
| Never | 1% |

91% of students felt comfortable after watching videos before coming to the class. Most students (64%) were able to glean information from the videos but needed help in class to fully understand the concepts. This result supports the idea that a purely lecture based class may not completely fulfill student learning needs (see Table 3).

Table 3. How Confident Did You Feel about the Material AFTER Watching the Lecture Video but BEFORE Coming to Class to Participate in Discussion and Activities?

| **Response** | **Rate** |
|---|---|
| Extremely confident | 27% |
| Not very confident | 9% |
| Somewhat confident but needed more help | 64% |

96% students felt comfortable after watching videos and after coming to class to participate in-class activities. Note that confidence levels for students who became extremely confident went up dramatically (45% increase) following class discussion and group activities. Using class time on activities rather than lectures opens up many opportunities to deepen student understanding and gives them a supported space in which to test their understanding in various applications. This leads to increased confidence in the material (see Table 4).

Table 4. How Confident Did You Feel about the Material AFTER Watching the Lecture Video and AFTER Coming to Class to Participate in Discussion and Activities?

| **Response** | **Rate** |
|---|---|
| Extremely confident | 72% |
| Not very confident | 4% |
| Somewhat confident but needed more help | 24% |

88% of students found pre and post quizzes for each section helpful. Students were not overwhelmingly against the Pre-/Post-Quiz process; however, it was noted in the free response results below that the Pre-Quizzes were less useful to them than the Post-Quizzes. It should be noted that Pre-Quizzes were used as a research tool for

this study. The Post-Quizzes, however, gave them an opportunity to test their understanding in an individual setting, and were probably the more useful of the two, based on response to this question (see Table 5).

Table 5. Did You Find the Pre- and Post-Quizzes for Each Section Helpful?

| Response | Rate |
|---|---|
| Always | 51% |
| Most of the time | 31% |
| Some of the time | 6% |
| Never | 12% |

Open-ended questions (6) and (7) yielded some thematic results, and select responses follow:

*What Have You Liked Best about the Flipped Classroom Environment?*

Out of total 157 students surveyed; 67 students responded to this open-ended question. Student‟s comments are grouped by similar theme and reproduced here are the examples of more than five comments:

- *I enjoyed having an idea of what was going to be discussed in the class before getting there. (21)*
- *The videos gave me a chance to kind of go back over the lessons if I was still confused on what something was, as well as provided me with some 1-1 understanding before I came to class. They also let me pause and take notes so when I came to the class, I was able to just focus on what you were doing.(18)*
- *I liked that we can focus on working on the problems in class instead of listening to a lecture. (14)*
- *Quizzes were helping to prepare us for each section to do good on the test. (8)*

We received a good bit of positive feedback, highlighting some of the pros that have been observed in other flipped classroom studies. It bears noting that many students were supportive of the video lectures, not just as preparation for in-class discussion, but as study tools they could look back at later. Students were also appreciative of the supported in-class time to practice and deepen their understanding.

*What Would You Change about the Flipped Format for Next Semester?*

Out of total 157 students surveyed; 62 students responded to this open-ended question. Student‟s comments are grouped by similar theme and reproduced here are the examples of more than five comments:

- *More in-class activities and homework (20)*
- *No changes should be made. (17)*
- *No pre-quizzes. (11)*
- *Maybe the time between sections; every other day we are on a new section with new material, so it was a bit faster than what I expected. Even though I did fine (despite this problem), others who may miss class certain days are behind, so maybe the time spent on each section should be extended or prolonged.(6)*

*•I liked mostly everything about the flipped classroom, but wished the videos weren't as lengthy and the videos were sometimes confusing. (5)*

Most notably, students wanted *more* work, both in and outside of class. This interesting suggestion showed up in numerous responses, emphasizing that students were not just willing and able to take on the extra outside of class time commitment, but eager for more. Many students suggested no changes at all, but there were also comments that reflected negatively on learning via video lecture. Particularly, students were put off by the length, and were sometimes left confused with no immediate avenue for getting their confusion resolved as they would have with an in-person lecture.

In summary, students seemed to value the flipped format as a complete process, though they had some misgivings about individual pieces. Student‟s satisfaction is linked to motivation and motivation linked to performance. Pre-Quizzes and video lectures were less appreciated, but when combined with in-class discussion and group activities, as well as the Post-Quiz and the ability to re-watch videos later on, the process seemed to work for many of the students. Clearly, as indicated by the quantitative results below, students learned as they worked through the process.

**Pre and Post Final Test**

We compared the data of the Pre-Final exam and Post-Final exam of students in the flipped classroom for both the instructors. Figure 3 shows pre and post final exam score on x- axis and student‟s grade on y axis. It represents student‟s grade for spring semester for faculty (S). Figure 3 showed an average 296% increase in comparing the pre-test scores to the post test scores.

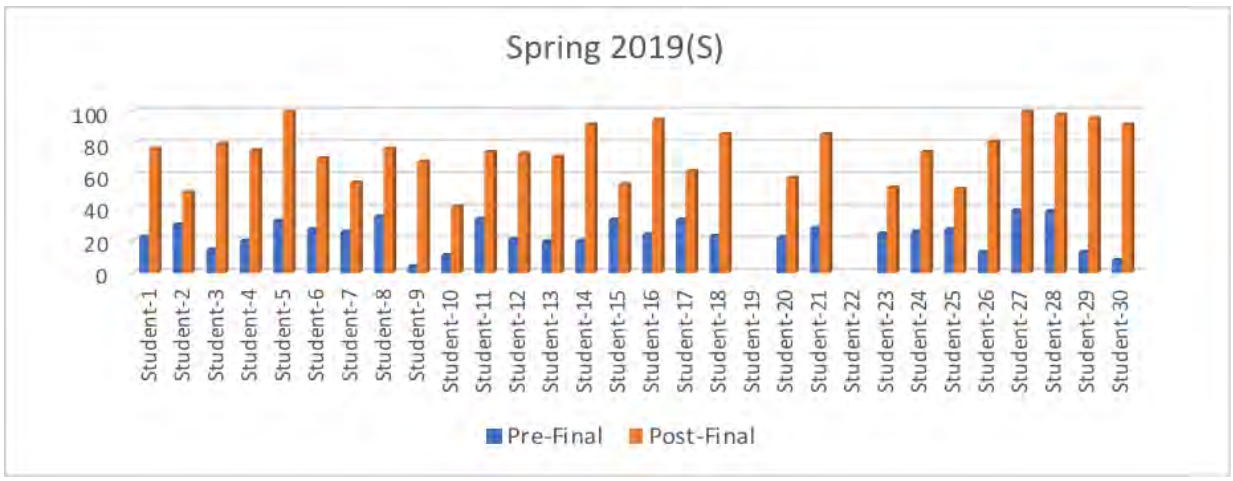



Figure 3. Pre-Final and Post Final Scores of Students for Spring 2019 for Faculty (S)

Figure 4 shows pre and post final scores of students for faculty(S) during fall 2019. Figure 4 showed an average 301% increase in comparing the Pre-Final scores to the Post-Final scores.

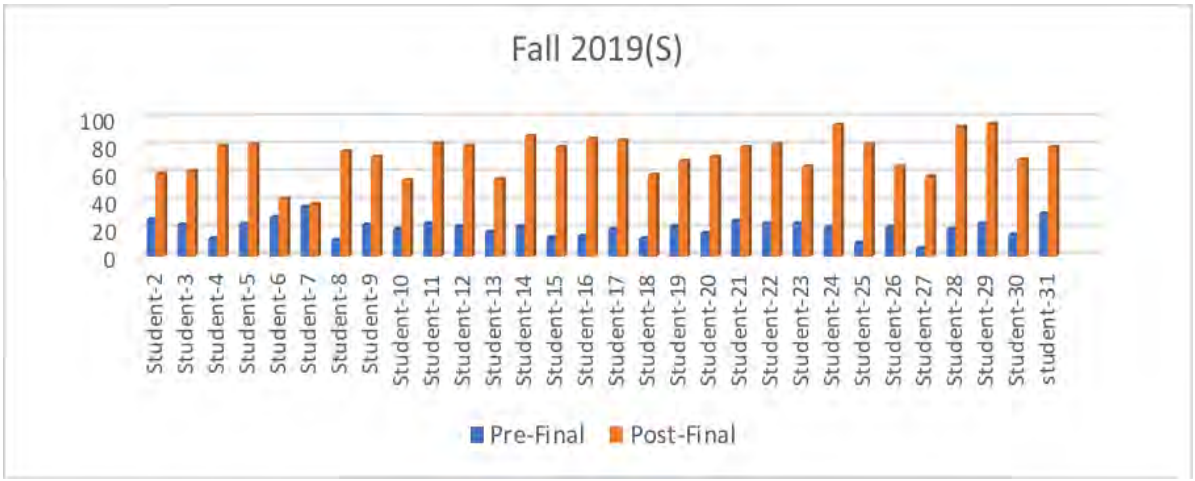



Figure 4. Pre-Final and Post- Final Scores of Students for Fall 2019 for Faculty(S)

Figure 5 shows pre and post final scores of students for faculty (M) during fall 2019. Figure 5 showed an average 110% increase in comparing the pre-test scores to the Post Final scores. The overall results indicate a significant increase in the Post Final score of students in the flipped classroom for both the instructors which ranges from 110% to 301%. We concluded that significant learning has occurred and flipped classroom teaching method has positive impact on first year mathematics student‟s performance.

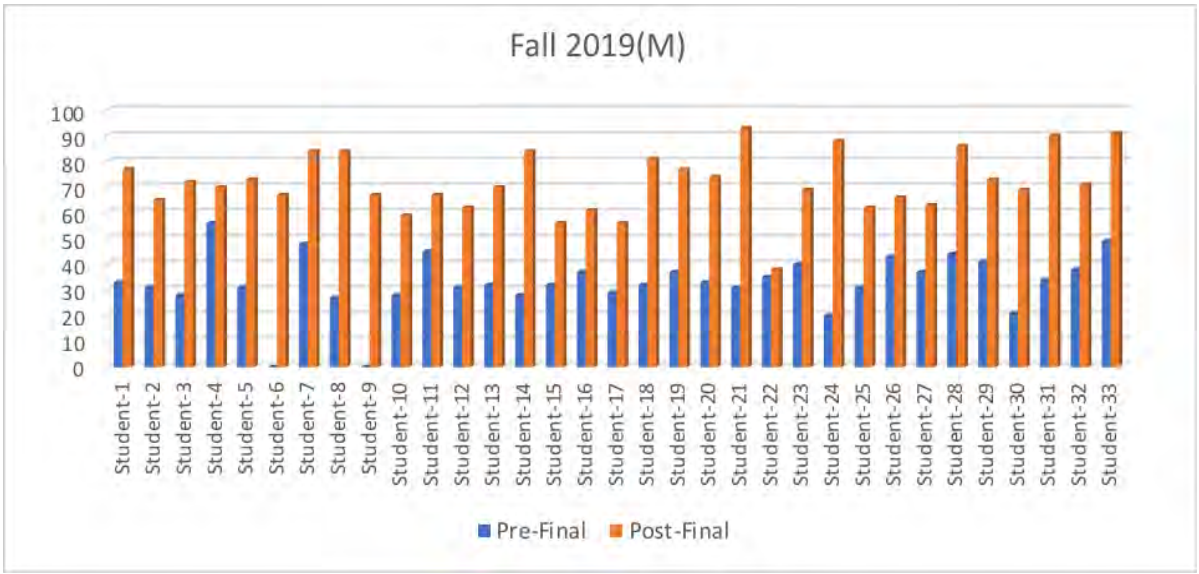



Figure 5. Pre-Final and Post -Final Scores of Students for Fall 2019 for Faculty (M)

We also compared the pass rate of the flipped classroom versus non-flipped classroom.125 students from the non-flipped method and 157 students from the flipped method participated in this study. The pass rate of non-flipped classroom students was 78.1% versus flipped-classroom students was 81.6%.

Figure 6 shows the pass rate of student‟s non-flipped and flipped classroom.

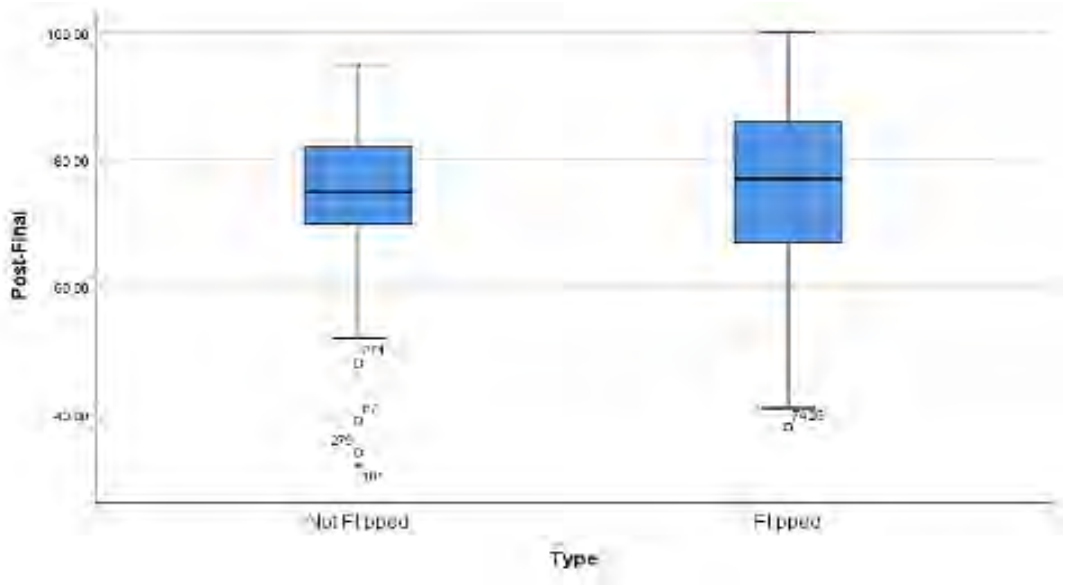



Figure 6. Student"s Pass Rate for Not Flipped and Flipped Method

Table 6 shows independent sample t-test for non-flipped and flipped classroom method. Independent sample t-test was performed to see if success in flipped classrooms is statistically significant. We checked both the methods (non-flipped and flipped) with hypothesis tests with 95% confidence intervals.

Table 6. Independent Sample t-test for Non Flipped and Flipped Classroom Method

| | | Levene"s Test for Equality of Variances | | t-test for Equality of Means | | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig.(2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Post-Final | Equal Variances Assumed | 2.841 | 0.093 | -.260 | 280 | .795 | -.39587 | 1.52300 | -3.3938 | 2.6021 |
| | Equal Variances not assumed | | | -.263 | 260.04 | .793 | -.39587 | 1.50423 | -3.3570 | 2.5653 |

Null hypothesis test $H_0: \mu_1 = \mu_2$ and Alternate hypothesis test $H_1: \mu_1 < \mu_2$ ; where $\mu_1$ is mean of the pass rate of non-flipped classroom method and $\mu_2$ is mean of the pass rate of flipped classroom method. We calculated p-value= 0.40 which is greater than 0.05; it is not statistically significant. Non-flipped classroom method did not do worse than the flipped classroom method. Flipped teaching methods essentially performed equally well compared to non-flipped methods.

## Discussion

We are encouraged by students‟ comments that directly commended the process and their improved understanding due to the structure of the course. Most notably, comfort and ease with the material was increased when students had the opportunity to come to class with some idea of what they would be learning more about. That is, of course, one of the goals of the Flipped Classroom. Students acknowledged that they felt a comfort because of this structure which they were not used to feeling in a math course. Many students indicated that they viewed videos multiple times – both before class and while preparing for tests –another advantage of flipped classroom format; a feature that a traditional in-person lecture format does not support. A dramatic improvement (45%) was noticed in students who felt extremely confident after watching videos and coming to the class for in class activity participation rather than just watching video alone. These results align well with earlier studies done by Enfield et al. (2016), Wasserman et al. (2017), and Gleason et al. (2011). This signifies the importance of in class activities and active learning helping students to clear their confusion and misconception and gain mastery in the content.

Our qualitative results not only suggest that students appreciate the non-traditional approach, but they also give us a roadmap for improvement. For instance, students may need further motivation to prepare *before* the class meetings in order to gain the most from that contact time. It could also be beneficial to re-edit or re-record lecture videos so that they are shorter and easier for students to digest before moving on. Finally, we noted that students want to practice even more than what was already required of them, perhaps through additional Post-Quiz questions.

We have compared the pre and post final test results of students of flipped classroom. The results showed improvement in student‟s score for both the faculties which ranges from 110% to 301%. We concluded that significant learning has occurred and flipped classroom teaching method has positive impact on first year mathematics student‟s performance.

Questionnaire results and final test results show improvement in student‟s satisfaction. These may be attributable in part to the fact that students are highly engaged with the material during the class time rather than passively taking notes, most students are actively trying to solve the problems. In the non -flipped format we rarely get to listen to students as they develop their solutions to problems. In the flipped classroom, we frequently observed students interacting with each other, justifying their reasoning, testing each other‟s claims, and correcting each other‟s mistakes. Earlier studies done by Herreid and Schiller (Herreid and Schiller 2013) also noticed significant peer to peer interaction and improved student engagement. Although students participated at different rates and levels when working in groups, it was certainly the case that many students were developing and stating their own solutions to the problems. In other words, they were *doing* math and not just listening to math. Flipped classroom changed the nature of our interaction with students. We frequently were able to watch the students at work, which allowed us to understand student‟s misconception and respond to them in a timely manner. When group did go off track, we had a challenge to decide when to intervene, and how much. We did not want to step in anytime, somebody said something wrong, because that would discourage

them from challenging their own and partner‟s assertions. On the other hand, we did not want to let a group spend half the class on an idea that would not work. We also tried to restrict ourselves to giving just enough help to get past the current obstacle rather than working a problem all the way to the end. These findings are in close alignment with earlier findings from Bishop and Verleger (Bishop and Verleger 2013) as well as Naccarato and Karakok ( Naccarato and Karakok 2015) which showed that instructors work more closely with students and able to provide more immediate and better feedback. Working effectively with students in small groups is a different skill than giving a good lecture. We both enjoyed working to improve our own skills.

Our study showed improved student‟s satisfaction. Post-test (final grades) improved significantly compared to pre-test. Pass rate did show some improvement, but it was not statistically significant amongst two teaching methods. One may argue that pass rate was about 75 to 80% in both formats and about 20-25% of students in any format with any faculty does not do well. These may be dependent on student‟s factor like their own motivation and individual baseline knowledge they are bringing to the class. We believe that improved students‟ satisfaction is linked to motivation and motivation is linked to performance. Faculties‟ confidence and skill set also improves with each attempt they make to teach using the flipped classroom. With consistent efforts from faculties and better design of flipped class we believe that student‟s pass rate may improve further.

There are limitations to this study. Though we have made an attempt here to compare the efficacy of the flipped classroom model to that of a non-flipped (traditional classroom), by comparing the pass rate of students of the both the formats, we cannot yet make a true direct comparison. The only true constants in play here are the instructors. Non-flipped classroom and flipped classroom had different students and different final exams. We used Pre-Testing only in the flipped format, and used entirely different final exams in the non-flipped formats. Despite this, we can at least assert that students did not do inferior in the flipped environment than in a traditional (non-flipped) setting. This gives us a reason to continue our work and do a more direct comparison between the two methods.

Furthermore, we believe that the most important disadvantage of flipped classroom method is the students not watching the videos prepared by the teacher, for various reasons. In our study about 23% of students reported they watched video only some of the time. Since theoretical teaching takes place outside the classroom, it may be difficult for teachers to follow whether or not the student is learning correctly or how much he or she has learned. In addition, it is difficult for students to ask instant questions and receive feedback in non-class activities. High technical requirements can also be considered as one of the disadvantages arising from the implementation process. Another setback of the flipped classroom activities is time demand, on the part of teachers as well as students. Studies done by Bergmann and Sams (Bergmann & Sams, 2014), Miller(Miller, 2012), Enfield(Enfield, 2016), Ramirez(Ramirez et al., 2014) Talbert (Talbert, 2014), Tiahrt (Tiahrt & Porter, 2016) showed similar concerns. We made it mandatory for our students to take the pre quiz before they can watch the video lecture. The post quiz which was considered a homework assignment will not open if they have not watched the video. Clear Communications and frequent reminders about deadlines to students improved some of the limitations in our study compare to previous studies.

## Conclusion

Our study showed improved student‟s perception of course satisfaction and improved final grades (post-test compared to pre-test). We noticed some improvement in pass rate of flipped classroom students compared to non-flipped classroom students, but it was not statistically significant. In the future, we are planning to compare both teaching methods by using the same pre and post final exams in both the flipped and non-flipped classes to compare more effectively. We also recommend future studies to see if this student‟s success transforms into improvement in student‟s attrition, retention, progression and graduation rate.

In summary, flipped class format has a bright future for improving teaching and learning in introductory level mathematics courses. This will be a new experience for many instructors and the amount of the time required to redesign a course is significant. In order to set up a course, there is more to be done than just preparing and posting content videos on the website. Providing faculties with clear explanations for the course design and more gadgets to engage students with course material often and early will ultimately lead to improve students‟ success. We are encouraged by the results of this small study, and plan to continue our work to make a more definitive statement on how the flipped format impacts student learning in other mathematics course.

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## Author Information

**Nehal J. Shukla**

https://orcid.org/0000-0002-5456-9556

Columbus State University

4225 University Avenue

Columb Columbus, GA, 31907

United States

Contact e-mail: *shukla_nehal@columbusstate.edu*

**Elizabeth McInnis**

https://orcid.org/0000-0001-9057-6385

Columbus State University

4225 University Avenue

Columbus, GA, 31907

United States