Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra

Fabian, Khristin; Esperanza, Peter; Toto, Criselda

Published in:
Adaptive and Adaptable Learning

Publication date:
2016

Citation for published version (APA):
Fabian, K., Esperanza, P., & Toto, C. (2016). Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra. In K. Verbert, M. Sharples, & T. Klobucar (Eds.), *Adaptive and Adaptable Learning: Lecture Notes in Computer Science* (Vol. 9891, pp. 85-97). Springer-Verlag. https://doi.org/10.1007/978-3-319-45153-4_7

This is an pre-print copy. For the published version refer to:
Esperanza, P., Fabian, K., Toto, C. (2016). Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra. In Verbert, K., Sharples, M., Klobucar, T. (eds) Adaptive and Adaptable Learning: Lecture Notes in Computer Science (Vol. 9891). Springer. doi: 10.1007/978-3-319-45153-4_7

Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra

Peter Esperanza[1,*], Khristin Fabian[2], Criselda Toto[3]

[1]Barstow High School, California, USA
Peter_esperanza@busdk12.com
[2]University of Dundee, Scotland
m.k.fabian@dundee.ac.uk
[3]Chapman University, USA
toto@chapman.edu

Abstract. In this study, we evaluated student perceptions of the flipped classroom model and its effects to students' performance and attitudes to mathematics. A randomized controlled trial with 91 high school algebra students was conducted. The experimental group participated in a year-long intervention of the flipped classroom model while the control group followed the traditional lesson delivery. Results of the year-end evaluation of this model showed positive student perceptions. An analysis of covariance of the algebra post-test score with learning model as treatment factor and pre-test as covariate resulted in a significant treatment effect at .05 level of significance. A paired-sample t-test by treatment group to compare pre-test and post-test math attitude scores resulted in a significant decrease in the control groups' value of mathematics while the experimental group had a significant positive change in their confidence and enjoyment of mathematics.

Keywords: flipped classroom; mathematics education; attitudes; student perceptions

1 Introduction

Past research has indicated that a strong grounding in algebra correlates to successful post-secondary education [1] but research has also shown that algebra students need more support to succeed as even students taking post-secondary level algebra classes are still inadequately prepared [2]. Among the strategies suggested to better prepare students include: provision of supplementary learning [3], promotion of conceptual understanding and procedural fluency in algebra [4] and the use of solved problems to engage students in analyzing algebraic reasoning and strategies [5]. These strategies appear to be a good match to the flipped classroom model.

Abeysekera and Dawson [6] characterizes the flipped classroom model as a change in use of class time and out-of-class time. Sometimes called the inverted classroom [7], this model utilizes a setup where previous homework activities are now done in class in the forms of active learning, peer learning and problem solving. Typical class lectures are then delivered via videos for out-of-class viewing. With this setup, less time is dedicated by the teacher to repeat information thus making it possible to provide students with more exercises and activities that promote conceptual and procedural fluency.

Reported benefits of flipped learning model include an increased student satisfaction, improved communication skills and consequently, an enhanced learning experience [8]. These findings, however are for higher education and evidence of positive effects of flipped learning in high school particularly those that examine student performance are limited [9]. To fill the gap in research, this study is conducted with high school students and focuses evaluation in student perception and performance.

This study aims to answer the following research questions:

RQ1. Is there an effect to students' performance in an algebra test when flipped classroom is adopted as a teaching model?

RQ2. Is there a change in students' attitudes to mathematics when flipped classroom model is used?

RQ3. How do students perceive the use of the flipped classroom model in terms of its usefulness in learning mathematics?

2 Review of literature

There is a considerable amount of literature that showcases positive student perceptions towards flipped learning. Some students feel that the use of lecture videos as preparatory material before class helped them understand the concepts better [10,11,12,13,14] and that the ability to pause and replay sections of the video allowed students to learn at their own pace [15,16,17,18]. The class activities, on the other hand, were more enjoyable, engaging and useful, [11], [15], [19,20,21]. In addition, the teacher in a flipped classroom model appears to be more available to provide guidance on difficult topics [12], [22]. Furthermore, this model has also fostered improved communication skills among students particularly their skills in communicating mathematical ideas [19].

Not all reports about flipped learning are positive. One of the frequently cited advantages of flipped learning is its ability to support students to follow their own pace through the use of the media controls available on the video lectures but some studies report that this utility is not fully utilized [10, 11]. Some studies note that students had difficulties in adapting this model [23,24,25]. Issues with flipped learning include: the lack of access to an expert while viewing the videos out of class [17], [23], [25]; that it required more effort and organization; and gives one the feeling of being left out when videos are not viewed prior to class [23], [25]. In fact, some students prefer the traditional model over the flipped classroom approach [18], [23].

Limited information is known about the effects of the flipped classroom model to students' attitudes towards mathematics. Only two studies [18], [23] used pre and post intervention data to measure change in mathematics attitude. Guerrero et al. [23] found that this model led to significant student gains in enjoyment and value of mathematics. In contrast, Young et al. [21], found that students in the flipped classroom had more negative attitudes towards mathematics after the intervention. The rest of the studies that covered students' attitudes were self-reports students provided at the end of the intervention. Weng [16] reported that students feel less anxious about mathematics as a result of using this model. Love et al. [14] found that using the flipped classroom format led to students having reasonably more positive outlook about the importance of mathematics to future careers. Similarly, Touchton [26] found that more students in the flipped classroom expressed an increased interest to take more advanced statistics courses. Lape et al. [17], on the other hand, found that students lacked the motivation to attend class because of the model. Given this gap in literature, it is the goal of this study to investigate the effects of using the flipped classroom model to student attitudes towards mathematics using before and after intervention data.

A literature search of flipped classroom implementations in mathematics and its effect to student performance yielded a limited number of results. A summary of these studies is listed in Table 1. There were studies that showed students in the flipped group outperformed their comparison groups [11, 12], [20], [22], [26]. Two studies had mixed results. Love et al. [14] found that while students in the flipped group initially outperformed the control group midway of the study, the control group was able to catch up towards the end of the intervention. Overmyer [27] found that students taught using the flipped classroom model by a lecturer with an experience in inquiry-based learning and cooperative learning performed better than the non-flipped group and those who were taught using the flipped model but with an inexperienced teacher. There were also studies that found student performance did not vary by teaching model [17, 18], [23] ,[28].

Student perceptions of a flipped classroom was not found to be an indicator of performance [11]. In general, however, studies that reported an improvement in students' performance also reported positive student perceptions and studies that reported no difference in student performance between the control and experimental group are the same studies that reported negative student perceptions.

All studies mentioned in this section were conducted at university level mathematics except for Muir et al. [13] and Kirvan et al.'s [28] work. Muir et al. reported positive student perceptions towards flipped learning while Kirvan et al.'s work found no difference in the performance of students who were taught using the traditional model of mathematics and students taught with the flipped classroom model. It is thus, another goal of this study to focus the evaluation of the flipped classroom to students' performance in high school mathematics, where student expectation and classroom setup is very much different to undergraduate level mathematics.

Table 1. Summary of findings related to student performance in mathematics

Study	Math Topic	Performance Measure	Results
[11]	Statistics	Course Grade and Final Exam	There was an improvement of course grades of EG ($p < .001$). Their final exam scores were also better than CG ($p < .001$).
[12]	Calculus	Exam	Students from EG performed better in their exams in comparison to the non-flipped class.
[14]	Linear Algebra	Exam	EG outperformed CG in the two midterm exams but by the final exam, the two groups' performance was not significantly different.
[17]	Differential Equations	Homework, Criterion Referenced Test (CRT), Exam	There was no difference between EG and CG's pre and post CRT scores ($p>.05$). The composite homework and exam scores of the two groups also showed no difference.
[18]	Calculus and Finite Mathematics	Exam and course grade	There was no statistically significant difference found between the experimental and comparison group.
[20]	Statistics	Exam, Grade and Standard Test	EG outperformed students in CG in their course grade ($p< .01$), exam grades ($p<.05$), and standard test ($p<.05$).
[22]	Algebra	Final exam scores	EG performed better than the CG ($p<.05$).
[23]	Finite Mathematics	CRT	There was no statistically significant difference between EG and CG at pre-test nor at post-test.
[26]	Statistics	Project	EG performed better than CG but the magnitude of this difference is small.
[27]	Algebra	CRT	EG taught by an experienced teacher in inquiry-based learning performed better than CG as well as those in the EG but taught by an inexperienced teacher.
[28]	Algebra	Standard Algebra Test	The similar magnitudes of the pre- to posttest effect sizes for the EG and CG suggest that the degree of difference in instructional focus had less of an effect in student performance.

Note: Students in the experimental group (EG) are students in the flipped classroom model. CG refers to the comparison group.

3 Methodology

3.1 Research design and nature of the intervention

The study adopted a randomized controlled trial to evaluate the effectiveness of the flipped classroom model. It took place in a public high school in a high desert area in California, USA. The school population is about 1380 students comprised of 26% Caucasian, 3% Asian, 55% Hispanic, and 16% African-American students where 70.6% of students are qualified in free or reduced price lunch.

Students were randomly assigned into two groups: flipped classroom model (experimental group) and traditional model (control group). Both groups participated in the study for the whole academic year. For the duration of the study, the experimental group received an average of three videos per week as part of the flipped classroom model whereas the traditional group received an average of three homework/practice exercises per week. All learning activities carried out in the experimental group was also carried out in the control group. For example, if the lesson includes 10 practice exercises, then the experimental group will work on these exercises within class hours. The control group will work on half of the exercises within class and the other half as assigned homework. A typical 50-minutes lesson structure and how it varies between groups is illustrated in Figure 1.

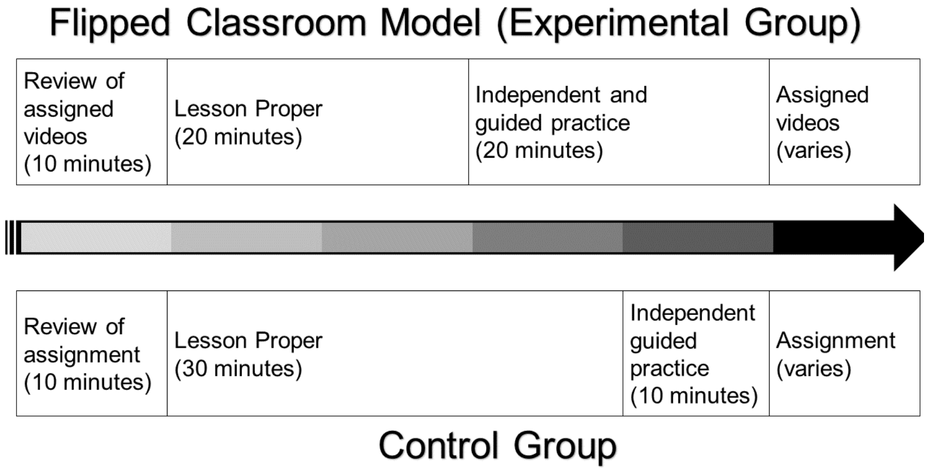

Fig. 1. Comparison of lesson structure in control and experimental group.

Learning activities for both groups include collaborative activities, problem solving, guided and independent practice, however, the videos are additional resources for the experimental group. For example, in one of the student projects, students took photos of the four different conic sections that they see outside the school and were asked to generate the equation of each conic section. Their task is to construct a poster that relates the photos they have taken to conic sections. This activity is a two-day paired activity and students worked together to finish all the work in class. The nature of the activity is the same for traditional and flipped classroom. The differences lie in the amount of time dedicated to classroom based learning activities and student implementation of the activities. For example, students in the flipped classroom accessed the flipped videos with their mobile devices to remind them of the concepts they need for the project. The questions they raised to the teacher was more about the output expected (i.e. how big should the poster or in what format). They were also able to finish the activity within the allocated time. Students in the traditional classroom, on the other hand, used the notes they took during class, their textbook and asked the teacher to review the concepts that they forgot. They also worked on the activity for two days but some students had to carry on doing the work at home as they weren't able to finish on time.

The videos used in the experimental group follows production using the Fizz Method [29]. Using this method, the videos have the following characteristic: minimal post-production, and usually completed in a single attempt; the teacher appears in the video and the notes are handwritten. The minimal post-production contributes to the simplicity of the video and easiness of video production. The talking head provides the non-verbal cues that might aid students and is also proven to be more engaging in online video formats [30]. The handwritten notes, as McCammon explains, is a form of modeling that allows students to see their thought processes and supports understanding.

3.2 Participants

A total of 91 second and third year high school students were randomly allocated into experimental and control group. There were 46 students (23 male, 23 female) in the control group and 45 students (24 male, 21 female) in the experimental group. The teacher participant taught both groups and has more 10 years of experience teaching high school mathematics and two years of teaching using the flipped classroom model.

3.3 Measures and Instruments

Attitudes towards mathematics inventory (ATMI). Tapia and Marsh's [31] attitude inventory for mathematics consists of four subscales with a test-retest reliability of .89. The subscales (with the corresponding number of questions and reliability scores are as follows): value of mathematics (10 questions, .70), enjoyment

(10 questions, .84), self-confidence (15 questions, 88) and motivation (5 questions, .78). Responses were scored using a five-point Likert-scale with 1 being strongly disagree and 5 being strongly agree. Negatively phrased items were reversed-scored. Scores on the ATMI subscale were computed for each student by adding the corresponding numerical score for each of the item on that subscale.

Algebra test. To measure student performance, twenty-five questions from the released California Standards Test [32] were randomly selected to be included in the study. The resulting test consists of multiple-choice questions with the following topic distribution: polynomial and rational expressions (9 items), quadratics, conics, and complex numbers (5 items); exponents and logarithms (5 items), series, combinatorics, and probability (6 items).

End activity evaluation. The end activity evaluation consists of five questions relating to student perception about the usefulness of the flipped classroom model. Questions were arranged in a 5-centimeter line marking scale with labeled endpoints (0 = strongly disagree; 5 = strongly disagree). Students rated their agreement with the statement by placing a dot on the line. The score was measured by measuring the placement of the dot from the left-hand side of the scale using a ruler. The higher the score, the higher the agreement with the statement. Students were also asked, in the form of open-ended questions, what they liked/disliked about the flipped classroom and suggestions on how to improve the current model.

3.4 Procedure

At the start of the term, students in the experimental group were given an orientation on the nature of the course. In the orientation, the experimental group were made aware that the purpose of the videos is to help them prepare for the next lesson and to cut down the time that they are allocated for note-taking in class. Their obligations, as such, is to watch the videos beforehand and summarize the video content and list down questions that they might have. An ATMI pre-test, followed by the algebra test the day after, was completed by both groups during the first two days of the semester. Students in the experimental group followed the flipped classroom model and the control group the traditional model as was illustrated in Figure 1. At the end of semester 2, students completed the ATMI and algebra post-test. An end activity evaluation was also completed by the experimental group.

4 Results and Discussion

4.1 Student performance

To compare the groups before and after the intervention, an independent t-test of the CST score was conducted. There was no significant difference between the experimental group (M=5.93, SD =2.50) and control group (M=5.96; SD =2.18), $t(89)= -.047$, p-value=.962, ES=0.01 but there was a significant difference in the groups test score at post-test, $t(89)=2.029$, p-value=.045, ES=–0.43. The experimental group (M=10.36, SD =3.10) performed better than the control group (M=9.02, SD =3.173). An independent t-test of the gains score, however, resulted in no significant difference, $t(89)=1.710$, p-value=0.09, ES= 0.59 but with a moderate effect size. This change is illustrated in Figure 2. To address the question whether the learning method had an effect in the post-test scores, an analysis of covariance (ANCOVA) was conducted. An ANCOVA of the post-test score with learning model as treatment factor and pre-test as covariate resulted in a significant treatment effect, $F(88)=3.23$, $p = .04$.

The findings of this study are in keeping with Van Sickel’s [22] work on Algebra as opposed to those studies that found no difference in the performance of experimental and control group [17, 18], [23], [28]. The length of the intervention of this study, however, is arguably longer than the previously cited studies so it is possible that the length of the intervention might have been a factor in the improved scores. It can be assumed that students over time became more familiar with the flipped classroom model and consequently was able to make better use of it to fit their learning styles. It is also worth noting that the instructor for this module had 11 years of teaching experience and has been using the flipped classroom model in the past 2 years. This supports Overmyer’s [27] findings that the experience of the teacher is a factor in running successful flipped classrooms.

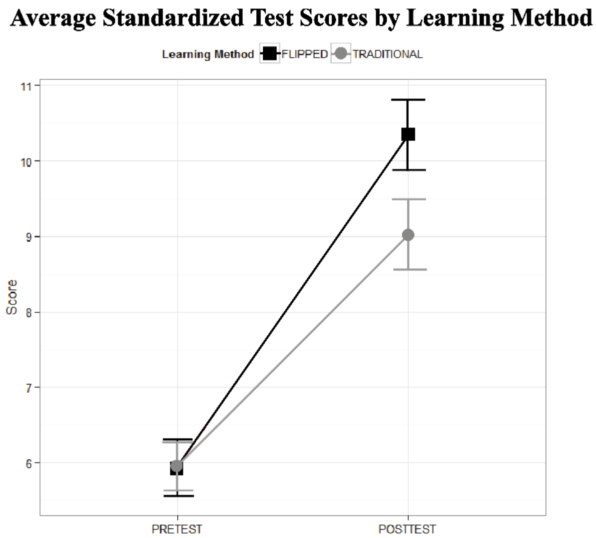

Fig. 2. Pretest and posttest scores of experimental and control groups

4.2 Attitudes towards mathematics

Table 2 shows the means and standard deviations of the ATMI scores of the experimental and control group. The gain scores were computed by subtracting the pre-test score from the post-test score. A positive difference in the score means an increase in students' attitude whereas a negative difference means otherwise. To test whether this change in score was significant a paired sample t-test was conducted for each subscale. To test whether the gains of the experimental and control group were statistically different, an independent t-test of the gains score was also computed.

For the subscale value of mathematics, the control group, had a significant change in their pre and post-test scores, t(45)=-2.74, p=.008, ES=-.21. In contrast, while the experimental group also had a decrease in score, this change was not significant, t(44)=-1.90, p=.064, ES=-.11. No other significant change was found in the control group. The experimental group, on the other hand had a significant positive change in their enjoyment of mathematics, t(44)=3.15, p=.003, ES=.47 and self-confidence t(44)=2.88, p=.006, ES=.43. The findings of this study has some similarities with Guerrero et al. [18] which also found significant gains in student enjoyment of mathematics although in this instance, students actually had lower value of mathematics at post-test in comparison to their pre-test score. This decline, however, was not as severe as Young's [16] study which resulted in more negative attitudes towards mathematics.

Table 2. ATMI Scores of Control and Experimental Group

	Value of mathematics	Enjoyment	Self-confidence	Motivation
Control				
Pre M(SD)	4.05(.51)	3.52(.75)	3.55(.82)	3.54(.79)
Post M(SD)	3.94(.62)	3.56(.84)	3.71(.80)	3.55(.94)
Gains M(SD)	-.10(.50)	.04(.56)	.16(.70)	.004(.87)
p- value	.008	.632	.119	.251
Effect size d	-.21	.07	.23	.01
Experimental Group				
Pre M(SD)	4.02 (.45)	3.36 (.66)	3.44 (.77)	3.50 (.72)
Post M(SD)	3.96 (.65)	3.62 (.65)	3.79 (.78)	3.61 (.82)
Gains M(SD)	-.06 (.58)	.26 (.54)	.34 (.80)	.12 (.67)
p- value	.064	.003	.006	.973
Effect size d	-.11	.47	.43	.17
Independent t-test on gains between groups				
p-value	.73	.06	.25	.50
Effect size d	.08	.31	.23	.15

4.3 Student evaluation of the flipped classroom model

Student evaluation of the flipped classroom model has been positive (see Table 3). The benefits of flipped learning as covered by previous studies were also observed in this study. This includes support to pace one's learning [15,16,17,18], improved communication channels [19], and improved understanding of mathematics concept [10, 11, 12, 13, 14]. Furthermore, students from this study also reported that they became more motivated to study math because of the flipped classroom model contrary to the findings of Lape et al. [17]. It is worth noting that Lape et al.'s study had different conditions—the study duration was shorter, on a different and more advanced math topic, with older students and with teachers who are relatively new to this approach. These factors may explain the differences in results.

Relationship between students' perception of the flipped classroom model against their gains in the algebra test and ATMI was also examined (see Table 4). There was a moderate positive correlation between students' gains in motivation and students' perception of the flipped classroom models' support for pacing ones' learning, r=.334. There was also a positive correlation between students' perception of the utility of the flipped classroom model to improve communication channels and their gains in value of mathematics, r=.348 and gains in motivation, r=.295. Contrary to Cilli-Turner's result [11], students' perception of the usefulness of flipped classroom to improve performance was found to be positively correlated to gains in the ATMI subscales and gains in the algebra test. Items relating to student motivation and preference to use this model had no significant correlation with the gains computed for this study.

Table 3. Student evaluation of the flipped classroom model

	Mean	SD
Q1. The flipped classroom allowed me to pace my own learning.	3.94	1.28
Q2. I feel that this model helped me communicate with my teachers and classmates.	3.34	1.48
Q3. I became more motivated to study maths as a result of the flipped classroom model.	3.80	1.39
Q4. I feel that my understanding of maths concepts has improved as a result of using this model.	4.44	0.82
Q5. I prefer the flipped classroom model over traditional lectures.	4.53	0.98

Table 4. Correlation between student evaluation and gains

	Gains Algebra Test	Gains Value Math	Gains Enjoyment	Gains Self-confidence	Gains Motivation
Q1	.201	.180	.145	.002	.334*
Q2	.123	.348*	.094	.146	.295*
Q3	.211	.115	-.012	.026	.260
Q4	.380*	.620**	.622**	.356*	.493**
Q5	.210	.120	.198	-.011	.249

*Correlation is significant at 0.05 level
**Correlation is significant at 0.01 level

In the open-ended questions, students from the experimental group explained what they liked/disliked about the flipped classroom model. Students appreciated the model because it allowed them to pace their own learning, go back to the videos when they have to and spend some time to reflect on the material as they take down notes for the topic covered in the video (n=18). One student explained *"I like how if I didn't understand something I could rewind the video and listen again--something I could not do if a teacher were lecturing in class*." This finding is consistent with the frequently quoted advantages of flipped learning model [15,16,17,18].

The lack of homework is also another thing they appreciated (n=17). As one student explained, the flipped model allowed her to "*not have to answer math problems that I don't understand at home.*" Instead, the students feel that as they are doing their homework in school, they in-turn receive more help (n=7). Students feel that this model have made them understand the topic better (n=7). In addition, students mentioned that the videos used to prepare for class allowed them more time to reflect and gives them an idea of what is going to happen in-class (n=3). Other advantages that students mentioned are: the chance to get more worked examples (n=3), its support for anytime, anywhere learning (n=3), and the opportunity it allows to make up for missed classes (n=1).

When asked about what they disliked about the model most of the students replied that they have no complaints about the setup (n=22) but a few have mentioned that they encountered difficulties accessing the video in some occasion (n=6) which in turn gives the feeling of having to catch up in class the next day. Another recurring issue is that the videos did not allow them to ask questions (n=5) so whatever question they have will have to wait for the next class. This ties in with their comments on how to improve the current model by having a comment section so that students can leave questions about the videos they just viewed. Overall, however, students were satisfied with the implementation and the recommendations for improvement have more to do with the interface design of the video channel rather than the content.

4.4 Limitations of this study

There are several limitations of this study. The sample size is slightly lower than the recommended sample size. To counter this limitation, we reported the effect to help us analyze the results. It is also possible that the order of the test at the end of the study might have affected the results. In the pre-test, ATMI was administered before the algebra test but in the post-test, this was not followed. Whether this had an effect to students' rating of their attitudes towards mathematics is not known. This leads to another limitation of the self-reporting nature of the two measures used in this study. For example, in the end evaluation of the study, the mean score of 3.8 for the question "I became more motivated to study because of the flipped classroom model" is a good indicator that students became more motivated but the change in ATMI-motivation was not significant. We have not addressed this limitation in this current study but for future research, we think it would be worthwhile adding qualitative data to the current design to validate these self-reports. Last, the videos used in this study are available on the web which the control group might be aware of. We had no way of monitoring whether the control group used these videos to support their learning needs or not. It is important to note, however, that the flipped classroom is not about the videos but about the structure of the course. Whether select students used these videos to help them with their assignments does not change the way control groups' classes were organized.

5 Conclusions and implications for research

The results of this study found that the use of the flipped classroom model had resulted to gains in student performance (#RQ1) and positive attitudes towards mathematics (#RQ2). We also found that students have positive perceptions about the usefulness of the flipped classroom model (#RQ3). We aimed to provide the same learning activities for the control and experimental group but admittedly the need to cover more material in class resulted to shortened learning activities in the control group and we believe that this is where the difference lies.

The videos that we used for this session were short 5 to 10-minutes videos. Keeping the videos to a minimum length is not just useful for production purposes but also for maintaining students' focus. The videos are, after all, meant to be preparatory materials for the next day's lesson and not substitutes to the actual discussion.

A lot of studies on flipped learning focused on the video element of the course but implementing the flipped classroom model required not just preparation of the videos to be used but also required planning of in-class activities. Successful implementation of a flipped classroom requires an agreement with the students that they will engage with the videos before class in place of the assignments that they are normally assigned. We believe that this preparation enables students to engage with the materials better in class and contributes to the success of the flipped classroom model.

Flipped classroom requires a lot of initial effort particularly in the preparation of video materials. For this study, the videos used were prepared and used the previous year so no further effort was required from the instructor in terms of developing new videos. We understand, however, that this is something those new to flipped learning would struggle with but it is also worth keeping in mind that the videos produced are reusable resources that teachers can build over time so this balances out the initial effort required.

References

1. National Mathematics Advisory Panel: Foundations for Success: The Final Report of the National Mathematics Advisory Panel. National Mathematics Advisory Panel. (2008)
2. Pinzon, D., Pinzon, K., Stackpole, M.: Re'modeling' College Algebra: An active learning approach.

Primus. 26, 179-187 (2016)
3. Sorensen, N.: Supplementary Learning Strategies to Support Student Success in Algebra I. Research Brief, American Institutes for Research (2014)
4. Smith, T.: Instructional Coaching Strategies to Support Student Success in Algebra I. Research Brief, American Institutes for Research (2014)
5. Star, J.R., Caronongan, P., Foegen, A., Furgeson, J., Keating, B., Larson, M.R., Lyskawa, J., McCallum, W.G., Porath, J., Zbiek, R.M.: Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students. Report, Institute of Education Sciences (2015)
6. Abeysekera, L., Dawson, P.: Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. Higher Education Research & Development. 34, 1–14 (2015)
7. Lage, M.J., Platt, G.: The Internet and the Inverted Classroom. Journal of Economic Education. 31, 11 (2000)
8. O'Flaherty, J., Phillips, C.: The use of flipped classrooms in higher education: A scoping review. The Internet and Higher Education. 25, 85–95 (2015).
9. Lowell Bishop, J., Verleger, M.: The Flipped Classroom : A Survey of the Research. In: Proccedings Annual Conference of the American Society for Engineering Education (2013)
10. Carney, D., Ormes, N., Swanson, R.: Partially Flipped Linear Algebra: A Team–Based Approach. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 641–654 (2015).
11. Cilli-Turner, E.: Measuring Learning Outcomes and Attitudes in a Flipped Introductory Statistics Course. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 833–846 (2015)
12. McGivney-Burelle, J., Xue, F.: Flipping Calculus. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 23, 477–486 (2013)
13. Muir, T., Geiger, V.: The affordances of using a flipped classroom approach in the teaching of mathematics: a case study of a grade 10 mathematics class. Mathematics Education Research Journal. 149–171 (2015)
14. Love, B., Hodge, A., Grandgenett, N., Swift, A.W.: Student learning and perceptions in a flipped linear algebra course. International Journal of Mathematical Education in Science and Technology. 45, 317–324 (2013)
15. McCallum, S., Schultz, J., Sellke, K., Spartz, J.: An Examination of the flipped classroom approach on college student academic involvement. International Journal of Teaching and Learning in Higher Education. 27, 42–55 (2015)
16. Weng, P.: Developmental Math, Flipped and Self-Paced. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 768–781 (2015)
17. Lape, N.K., Levy, R., Yong, D.H., Haushalter, K.A., Eddy, R., Hankel, N.: Probing the inverted classroom: A controlled study of teaching and learning outcomes in undergraduate engineering and mathematics. 121st ASEE Annual Conference and Exposition. (2014)
18. Zack, L., Fuselier, J., Graham-Squire, A., Lamb, R., O'Hara, K.: Flipping Freshman Mathematics. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 803–813 (2015)
19. Murphy, J., Chang, J.-M., Suaray, K.: Student performance and attitudes in a collaborative and flipped linear algebra course. International Journal of Mathematical Education in Science and Technology. 47, 653-673 (2016)
20. Wilson, S.G.: The Flipped Class: A Method to Address the Challenges of an Undergraduate Statistics Course. Teaching of Psychology. 40, 193–199 (2013)
21. Young, A.: Flipping the Calculus Classroom: A Cost-Effective Approach. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 713–723 (2015)
22. Van Sickle, J.: Adventures in Flipping College Algebra. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 600–613 (2015)
23. Guerrero, S., Beal, M., Lamb, C., Sonderegger, D., Baumgartel, D.: Flipping Undergraduate Finite Mathematics: Findings and Implications. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25, 814–832 (2015)
24. Strayer, J.F.: How learning in an inverted classroom influences cooperation, innovation and task orientation. Learning Environments Research. 15, 171–193 (2012)
25. Chen, Y., Wang, Y., Kinshuk, Chen, N.S.: Is FLIP enough? or should we use the FLIPPED model instead? Computers & Education. 79, 16–27 (2014)
26. Touchton, M.: Flipping the Classroom and Student Performance in Advanced Statistics: Evidence from a Quasi-Experiment. Journal of Political Science Education. 11, 28–44 (2015)
27. Overmyer, J.: Research on Flipping College Algebra: Lessons Learned and Practical Advice for Flipping Multiple Sections. Problems, Resources, and Issues in Mathematics Undergraduate Studies. 25,

792–802 (2015)
28. Kirvan, R., Rakes, C.R., Zamora, R.: Flipping an Algebra Classroom: Analyzing, Modeling, and Solving Systems of Linear Equations. Computers in the Schools. 32, 201–223 (2015)
29. McCammon, L.: Fizz Method, http://lodgemccammon.com/flip/research/fizz-method/
30. Guo, P.J., Kim, J., Rubin, R.: How Video Production Affects Student Engagement : An Empirical Study of MOOC Videos. In: Proceedings of the first ACM conference on Learning @ scale conference. 41–50 (2014)
31. Tapia, M., Marsh, G.E.: An Instrument to Measure Mathematics Attitudes. Academic Exchange Quarterly 8, 16–21 (2004)
32. California Department of Education: California Standards Test, http://www.cde.ca.gov/ta/tg/sr/documents/cstrtqalgebra2.pdf