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Abstract

This literature review investigates the effectiveness of the flipped classroom model in secondary mathematics classes, specifically the types of modifications and strategies teachers have used to help improve student motivation and academic success. The use and availability of technology in the classroom keeps increasing. Many classrooms now have access to tools and resources that they could only dream about ten years ago. Educators have adapted teaching styles and strategies to align with the new growth of technology. With so many technology options now available to students and teachers, the flipped classroom model offers flexibility to adapt the learning to the individuals in the classroom. The literature review will utilize peer reviewed, scholarly journals to present an in-depth exploration of the effectiveness of the flipped classroom model in secondary mathematics classes.

Investigating the Potential of the Flipped Classroom Model in Secondary Mathematics

The most popular teaching style used in secondary education is inquiry-based discussions and traditional lecture-based teaching. School districts have started sending teachers to several classes or professional development opportunities that have opened teachers' eyes to the potential of using technology in their own classroom. One of the most common uses for technology in the classroom is creating online lessons or videos. This can help teachers who are absent continue their lesson plans without having their student's waste time on busy work or review material while they are gone. Many of my students enjoy watching videos in their spare time, so connecting what they do outside the classroom to an activity inside the classroom should theoretically increase the students' link with the learning.

After attending the technology classes, some teachers change their entire curriculum and record videos for each class. Other teachers continue traditional methods of teaching in-class, but also record videos of the lessons so that students can go back and watch later. The idea behind this concept is to help absent students or struggling students catch up with the material. The students all have the ability to re-watch the material and catch up if they are not understanding a concept. The flipped classroom model can solely rely on videos and online resources to teach the material or it can be used as a tool to provide videos for students who are behind on the material or understanding. Investigating the true effectiveness of the flipped classroom models in a secondary mathematics class becomes important as more teachers are choosing to use this model in their own classrooms. The aim of this literature review is to investigate the potential us of the flipped classroom model in secondary mathematics courses. Through an evaluation of the current literature, studies, and research, this literature review will

examine the strengths, weaknesses, and gaps within the flipped classroom model when compared to a traditional lecture-based teaching model.

The most accepted definition of the flipped classroom model is extremely broad and subject to interpretation. The definition given by Lage, Platt and Treglia (2000) states that the flipped classroom model occurs when "the events that have traditionally taken place inside the classroom now take place outside the classroom and vice-versa" (p. 32). Nowadays, many educators utilize videos or other online content to replace the traditional direct instruction parts of their lessons. Prior to using videos and the internet, educators were still able to develop flipped classroom models for their classes.

A flipped classroom model uses technology, often videos, to deliver instructional content. In the last 20 years, this model has become more popular and widely used by educators around the world. Many educators have modified the general idea to fit their own classes, and there have been several studies done about what can make the flipped classroom model effective. Teachers have adapted their own strategies and models of how to incorporate the flipped classroom model into their own teaching style. This literature review will look at the effect the flipped classroom model has on student learning and achievement, the modifications, strategies, and models that have been shown to increase student motivation and achievement, and the overall strengths, weaknesses, and gaps.

Literature Review

The flipped classroom model has developed and evolved throughout the last 20 years. The exact history is not agreed upon in many of the scholarly journals. An article by Matsuda, Azaiza and Salani (2017) outlined the idea that the flipped classroom model was first used by Harvard professor Eric Mazur, "who in the late 1990s utilized a strategy called peer instruction,

which involved having his physics students complete preclass work so that they could interact with one another and engage with the professor during class" (p. 32). However, an article by Hawks (2013) claims that the flipped classroom model started in 2007 when two chemistry teachers, Bergmann and Sams, started making video lessons for athletes who were routinely absent from their classes. Even though the precise history of the flipped classroom model is contested, every article agrees that the flipped classroom model usage has increased dramatically within the last five years. "Flipped instruction has now reached the point where more than two-thirds of teachers in the United States report flipping a lesson, if not an entire course" (de Araujo, Otten & Birisci, 2017, p. 248). Since the flipped classroom model is being utilized more within the classrooms, there have been a multitude of studies done on specific aspects of the flipped classroom model. Teachers may have a hard time finding and analyzing these studies because the research done in them can be specific to a course, age group, and/or time period. The goal of this literature review is to collect and analyze multiple studies about the impact that the flipped classroom model has had on secondary mathematics courses.

Bhagat, Cheng-Nan, and Chun-Yen (2016) provided an extensive study examining the impact of the flipped classroom model on learning at a high school level. The following three research questions were used to measure the impact:

1. "Is there any significant difference in the learners' achievement scores between the experimental and control groups?
2. Is there any significant difference in learners' motivation between the experimental and control groups?

3. Are there any significant differences in learners' performance for students of different achievement levels between the experimental and control groups?" (Bhagat, et al., 2016, p. 136)

The study took place over six weeks. All of the participants were 14 or 15 years old. Prior to implementing the flipped classroom model, the researchers categorized each student based on their previous summative scores in their mathematics class. There were 31 students categorized as high achievers, which means their scores were between 75 and 100. There were 35 students categorized as average achievers, which means their scores were between 60 to 74. Finally, there were 16 students categorized as low achievers, which means their scores were below 60. The 82 students were arranged into two groups of 41. The control group consisted of 24 male students and 17 female students. There were 14 high achievers, 19 average achievers, and 8 low achievers in the control group. The experimental group consisted of 28 male students and 13 female students. There were 17 high achievers, 16 average achievers, and 8 low achievers in the experimental group. Every student took a pretest, posttest, and course interest survey during the study. The students in both groups covered three topics of trigonometry: introduction to trigonometry, trigonometric ratios, and trigonometric identities (Bhagat, et al., 2016).

The control group spent 30-40 minutes each day engaging in traditional lecture and discussion in class. The remaining 10-20 minutes were used for problem solving. Each student was expected to complete textbook problems as homework on their own time after class each day.

"On the other hand, in the experimental group, pre-recorded video lessons were uploaded to the dropbox the week before class. The average duration for each lesson was 15 to 20

> minutes. Students were asked to watch the video lesson before coming to the class. During classroom time, students were engaged in the activities based on the video lessons. Students were divided into groups to discuss the textbook problems. In the meantime, the students who needed remedial assistance were given face-to-face support." (Bhagat, et al., 2016, p. 137)

The study used Mathematics Achievement Test (MAT) to measure the students' performance via the pretest and posttest. The tests contained 15 identical, multiple-choice questions placed in a different order. The students had 35 minutes to complete the tests. In order to measure students' motivation in the different instructional settings, the Course Interest Survey (CIS) was given. The CIS questionnaire has 34 items designed to reliably measure attention, relevance, confidence, and satisfaction. Once the MAT testing was complete, ANCOVA was applied to analyze the results. After the CIS questionnaire was finished, MANOVA was used to analyze attention, relevance, confidence, and satisfaction as dependent variables. For both the ANCOVA and MONOVA analysis, the statistical significance level was $p < 0.05$ (Bhagat, et al., 2016).

The results of the ANCOVA analysis showed that the experimental group and control group significant overlapping in the pretest, but the experimental group outperformed the control group in the posttest. Since the experimental group was facilitated using the flipped classroom model, these results suggest that the flipped classroom model improved the learning achievement of the students in the experimental group. "The results of MANOVA revealed that there was significant difference for attention, relevance, confidence, and satisfaction between the experimental and control groups" (Bhagat, et al., 2016, p. 140). Students seemed to be more satisfied and positive when learning in a flipped classroom approach. These results indicated an

increase in student motivation when utilizing the flipped classroom model. Furthermore, the findings also showed that the low achievers in the experimental group outperformed the low achievers in the control group while the high and average achievers learning rates remained about the same. Bhagat, et al. (2016) asserted that these results showed that the flipped classroom model may help improve low achievers' performance in mathematics by stating, "This study has also shown that the flipped classroom benefits lower achievers more than high and average achievers" (p. 140).

Kevin Clark (2015) completed a study the effectiveness of the flipped classroom model. This study focused on student performance, motivation, and engagement. The participants in this study where 42 Algebra 1 students, 18 males and 24 females, between the ages of 13 and 15 years old. Permission for the study was granted by the organization's Institutional Review Board, the students participating, and the students' parents/guardians. The study took place over seven weeks covering solving and graphing systems of equations and inequalities. Prior to each class day, the students were asked to watch videos, listen to podcasts, read articles, and/or view presentations while completing a guided notes workbook. The notes in the workbook were used to determine if the students were adequately prepared for the class. During class time, the students participated in hands-on learning activities, real-world applications, and independent practice (Clark, 2015).

During the study, both quantitative and qualitative data was collected and analyzed. Quantitative data was collected through a pre-study survey, a post study survey, and a teacher-created assessment. The pre-study and post study survey used was the Student Perception of Instruction Questionnaire (SPIQ). The survey responses were recorded using a Likert scale rating. The mode was then calculated to analyze the results. The teacher-created assessment

was scored using the preapproved district grading scale. The measures of central tendency and variance were then calculated. To analyze the results, the assessment was compared to assessment data gathered in previous years. Independent-sample t-test was used to determine if there was a significant different between the flipped classroom model and the previous traditional instruction approach (Clark, 2015).

The quantitative results showed no significant difference between the traditional and flipped classroom approaches to instruction and learning.

> "There was not a significant difference in performance between those students taught using the flipped model instruction ($M = 80.38$, $SD = 11.02$) and those who were in the traditional classroom environment ($M = 80$, $SD = 11.56$); $t(80) = 0.15$, $p = 0.44$. These results suggested similar performance abilities between the traditional and flipped classrooms on the content covered on the unit test." (Clark, 2015, p. 102)

However, the quantitative data did show an increase in student engagement. The surveys showed that 88% of the students actively participated in all aspects of the flipped classroom model compared to 76% of the students actively participating in all aspects of the traditional classroom approach (Clark, 2015).

The qualitative data was gathered using randomly selected student interviews, a focus group session, and daily journal observations made by the researcher. Twelve students were randomly selected for the student interviews, and ten students were randomly selected for the focus group session. The qualitative data was analyzed using captured keywords and coding responses. Clark (2015) describes the process by writing,

> "Beginning on the first day of the flipped classroom intervention, the process of looking for recurring themes began. As the observations continued and the interviews started, a

> constant state of comparison from one day to the next and one interview to the next transpired in order to expand, contract, delete, or add codes and categories. The qualitative data was analyzed and revisited until the point of saturation was reached." (p. 100-101)

The qualitative analysis of the student interviews, focus group, and research journal showed the following keywords and phrases as overall themes throughout the flipped classroom model: active engagement and learning, class time and structure, quality of instruction, collaboration, and communication. The analysis showed a more student-centered environment when compared with the traditional classroom environment. The students demonstrated the ability to interpret and communicate their solutions with other students and the teacher. These results indicate an increase in student engagement in a flipped classroom model when compared to the traditional classroom model (Clark, 2015).

Chung Kwan Lo (2017) also examined the impact that the flipped classroom model has on student attitudes and engagement in a mathematics classroom. He also focused his research on possible improvements that can be made to increase the effectiveness of the flipped classroom model. According to Lo (2017): "[This study] was guided by the following research questions:

1. What are the student attitudes and engagement within a flipped mathematics classroom?
2. How can the design of our flipped classrooms be improved?" (p. 624)

There was a total of 130 eighth grade students that participated in the research. There were also four mathematics teachers who were involved in facilitating the instruction and gathering data. The research was done throughout two separate cycles consisting of the following four stages: plan, action, observation, and reflection. Throughout the planning stage, three researched-

backed decisions were made. The first was that the instructional videos would be limited to six minutes or less. As Lo (2017) explains, "the literature reported that students are likely to drop out of a long instructional video" (p. 624). The second decision was to include a quiz after each instructional video to monitor each student's progress and participation. By using Moodle, an online program, the students and teachers were able to get instant feedback on their learning and growth. The third decision was to include meaningful mathematical dialogue in the classroom. This dialogue could be between the teachers and the students or the students amongst themselves in a small group setting. The facilitators created structured discussion questions and extra advanced problems for these daily, small group discussions. By using these planning decisions, the classroom lessons were structured the same way. The students would watch two to three instructional videos, complete an online quiz using Moodle, get teacher feedback based on the quiz performance, and then participate in small group discussions about more advanced problems (Lo, 2017).

In order to collect data on the research, the teachers provided peer observations and self-reflections. The teachers commented on the effectiveness of the flipped classroom model, as well as, a multitude of interventions and strategies that they used to address certain problems that arose during the lessons. The student participants took a questionnaire about their attitudes, behavioral engagement, emotional engagement, and cognitive engagement. This questionnaire was designed using a 5-point Likert scale (Lo, 2017).

After the first research cycle, the teacher facilitators sat down together to reflect on their flipped classroom model. They found that many aspects worked well. Such as, the students seemed to be adequately involved in the instructional videos and follow-up quizzes. Students were able to answer similar revised questions posed at the beginning of class. The teachers were

concerned about the lack of engagement inside the classroom and small group discussions. Many students were preferring to answer the questions individually instead of in a small group setting. Prior to starting the second research cycle, the teacher facilitators looked for strategies to help improve student engagement in the classroom. The researcher decided to use group competitions.

> "For example, we designed an activity that required students to apply their knowledge of 'the converse of the Pythagorean theorem'. The goal of this activity was to determine as quickly as possible if a triangle is a right-angled triangle. Students worked in pairs and discussed their best strategy to solve the problems. After that, teachers showed some triangles to the class and the competition began. Competition, we hoped, would spur our students to communicate ideas, validate their thinking processes, and solve the problems collaboratively. Specially, this pair activity was intended to enhance students' understanding of the Pythagorean theorem." (Lo, 2017, p. 626)

After the second research cycle, the teachers got together again to discussion the student engagement. They all reported similar engagement in the videos and online quizzes. They also observed that students were more willing to discuss results and ideas with their peers after engaging in the in-class competitions. These observations were backed by the results from the student questionnaire. "The student ratings in the second cycle were significantly higher than those in the first cycle in terms of course evaluation and the three constructs of engagement" (Lo, 2017, p. 626).

Theodore Hodgson, Abby Cunningham, Daniel McGee, Lenore Kinne, and Teri Murphy (2017) designed and implemented their own study to assess behavioral engagement in flipped classrooms. Hodgson et al. focused primarily on teachers' abilities and other potential factors

could affect the behavioral engagement in a flipped and non-flipped mathematics classroom. "The study focuses on behavioral engagement because (1) there is a documented relationship between engagement and students achievement, (2) this dimension of the engagement construct has not received significant research attention, and (3) the researchers believe that independent observational assessments of engagement may be more valid and reliable than self-report assessments" (Hodgson, et. al., 2017, p. 250). This study was unique in that it focused on both the flipped classroom approach, as well as, the traditional approach. The overarching research question addressed was is there a measurable difference in behavioral engagement in the flipped classroom and non-flipped classroom? (Hodgson, et. al., 2017)

The study done by Hodgson, et al. was performed in three different settings. The first setting was in a suburban high school algebra 1 class of 27 ninth-grade students with 30.2% qualifying for the free and reduced lunch program. The teacher in first setting has been teaching for 16 years with a middle grades (5-9) mathematics endorsement. She is known as a highly effective teaching, and she was a recent finalist for the Presidential Award for Mathematics and Science Teaching. The second setting was in a suburban high school algebra 2 class of 24 eleventh and twelfth-grade students with 40% of the students qualifying for the free and reduced lunch program. The teacher in the second setting has been teaching 26 years with a secondary mathematics endorsement. The third setting was a rural seventh-grade general mathematics class of 26 students with 67.7% qualifying for the free and reduced lunch program. The teacher in the third setting has been teaching for six years with both a secondary and middle-grades mathematics endorsements. Prior to the study, all of these teachers participated in a five-day professional development workshop on the flipped classroom instructional approach. In order to compare engagement between the flipped classroom and non-flipped classroom approaches, the

researchers selected two consecutive units for each teacher. In the first and third settings, the first unit was taught using the non-flipped classroom approach, while the second unit was taught using the flipped classroom approach. In the second setting, the first unit was taught using the flipped classroom approach, while the second unit was taught using the non-flipped classroom approach (Hodgson, et. al., 2017).

Data was collected over twelve lessons from each setting by two observers, who were trained to monitor behavioral engagement. One of the observers was a mathematics educator, and the other observer was a pre-service teacher. Each observer watched the same lessons, but sat on opposite sides of the classroom. Each observer selected six students to focus their observations upon each lesson. The observers used a modified technique created by Deslauriers, Schelew, and Wieman to mark down their observations of the students at five minute intervals throughout each lesson. Each of the six students were scored based on if the student was engaging in on-task behaviors or off-task behaviors during each five-minute interval. These scores were then totaled to obtain a total engagement rating for the lesson (Hodgson et. al., 2017).

The results show that there was not a lot of difference in engagement between a flipped classroom approach and a non-flipped classroom approach. In the first setting, the teacher had an engagement level of 5.4 for the flipped classroom approach and 5.6 for the non-flipped classroom approach. The teacher in the second setting had an engagement level of 2.55 during the flipped classroom model and 2.5 in the non-flipped classroom model. The teacher in the third setting had an engagement score of 4.66 during the flipped classroom lessons and 3.5 during the non-flipped classroom lessons. Hodgson, et al. summed up their findings nicely by stating, “Our research suggests that those examining the impacts of flipped instruction cannot

simply vary the instructional approach (flipped versus non-flipped), but must also consider the actions of the teacher, characteristics of the students, and other contextual factors" (p. 257). These results indicate that the teaching method used might not affect the learning or engagement nearly as much as other research has shown. There could be modifications or strategies that occur in both flipped and non-flipped classrooms that influence learning and engagement more so than the instructional method (Hodgson, et. al., 2017).

Another study that compared the learning done in a flipped-classroom and a traditional classroom was executed by Joshua DeSantis, Rebecca Van Curen, and Jake Putsch. The focus of their study was whether or not students learn more in the flipped classroom. This study was distinctive because it focused on students learning a single lesson about points of concurrency. Most other research done comparing the flipped classroom approach to a non-flipped classroom approach focus on either different units or multiple skills (DeSantis et al., 2015).

The forty-seven participants in this study were high school students from Maryland enrolled in two sections of the same Geometry course. The students were divided into two groups. The first group had twenty-one students with an average grade of 87%. The second group had twenty-six students with an average grade of 80%. The average grade percentages were collected prior to the study. According to DeSantis et al. (2015), the aim of the research was to answer the following two questions,

1. "Do students achieve a superior understanding of points of concurrency from a lesson delivered using a flipped lesson paradigm than students who learn from a lesson delivered using a traditional lesson paradigm?

2. Do students who receive instruction on points of concurrency in a flipped lesson format rate the quality of their instruction differently than students taught using a traditional lesson format?" (p. 45)

The flipped lesson format that was used in this study was adapted from the experimental learning theory (ELT), which utilizes games, simulations, experiments, online videos, blogging, and finally, student demonstration of their learning via a performance or demonstration (DeSantis et al., 2015).

The study began with all of the students taking a pre-test over points of concurrency. This pre-test included ten multiple-choice questions to assess the students' current understanding of points of concurrency. The study ended with all of the students taking a ten-multiple-choice question post-test over points of concurrency and a self-reflection of learning survey. The self-reflection survey had twelve items that were scored using the Likert scale and five open-ended response questions. The middle of the survey consisted of the instruction over points of concurrency. The first group participated in the traditional learning format. The traditional learning format included a warm-up activity, a traditional lecture over the points of concurrency utilizing a PowerPoint presentation, a small group discussion, and an individual worksheet to demonstrate the students' level of learning. The second group participated in the flipped learning format. The flipped learning format included an online video, a guided notes handout, small group discussion, one-on-one instruction from the instructor if needed, and an individual in-class activity guide to demonstrate the students' level of learning. The individual activity was kept the same for both groups (DeSantis et al., 2015).

DeSantis et al. (2015) used the data collected through the pre-test and post-test to evaluate whether or not students achieve a superior understanding of the points of concurrency

with a flipped classroom or traditional classroom approach to learning. The pre-test showed that the traditional learning group had an average score of 2.24 and the flipped classroom learning group had an average score of 2.31. The post-test showed the traditional learning group had an average score of 4.14 and the flipped classroom learning group had an average score of 3.96. These results between the two groups in both the pre-test and post-test scores are not significantly different. DeSantis et al. (2015) concluded, "Our findings indicated no difference in the learning outcomes of the students who learned from a traditional lesson and students who learned from a flipped lesson" (p. 51).

DeSantis et al. (2015) used the post-lesson feedback survey to determine how the students rate the quality of their instruction using the flipped classroom model or the traditional classroom model. The traditional group had an average score of 2.36. The flipped classroom group had an average score of 2.72. The researchers concluded that the students who learned using the flipped classroom lesson were significantly less satisfied with their instruction than students who learned during a traditional classroom lesson. DeSantis et al. (2015) explain further by stating, "While the finding from the present study do not indicate that flipped lesson planning is more effective than traditional forms of instruction, this does not necessarily rule out the possibility that adopters of the flipped lesson paradigm may experience success in other contexts" (p. 51). The researchers also note that the efficacy of the flipped classroom is highly dependent on the teachers who implement it and the specific learning needs of students in each individual classroom (DeSantis et al., 2015).

Tracey Muir and Vince Geiger (2016) performed a study which focused on outlining the possible benefits and/or possible detriments offered by a flipped classroom approach within a secondary mathematics classroom. In addition to focusing on possible advantages or

disadvantages to the flipped classroom model, Muir and Geiger (2016) investigated a single teacher's attempt to incorporate the flipped classroom approach from the teacher's previous traditional teaching style. To guide the research, Muir and Geiger (2016) outlined the following research questions:

1. "What is the nature of a teacher's attempt to incorporate a flipped classroom approach into a year 10 classroom, working within a highly structured mathematics curriculum/subject?
2. What are the teacher's and student's perspectives on the benefits or otherwise of the facilities offered by a flipped classroom approach within the context of a grade 10 mathematics class?" (p. 130)

This study was conducted with one teacher and twenty-seven grade 10 extended mathematics class in Tasmania over one school year. Of the twenty-seven students, 17 were male and 10 were female. All of the students were around 15 years old. The students were 1:1 with iPads and had access to many online tools including videos, textbooks, and workbooks. The majority of the students had no previous experience with the flipped classroom approach. The teacher had already preformed a couple of flipped classroom trials, but this was the first time that he used the flipped classroom approach for an extended length of time. The extended mathematics course is open to every student at this school who is in grade 10, and it does not have any required pre-requisites. However, the majority of the students who enroll in this extended mathematics course are aiming to study mathematics in the future. The topics covered in the extended mathematics course are algebra, functions, graphs, calculus, and probability. The students were encouraged to work at their own pace, and they were required to show mastery of each content skill by watching the videos, completing the exercises, and mastering the

assessment task for each unit. When a student had mastered one unit, they would then move on to the next unit. As the year progressed, the number of different topics that were being learning within the classroom increased considerably (Muir & Geiger, 2016).

The data that was gathered throughout the school year was both quantitative and qualitative. One of the collection instruments was Qualtrics, which is an online survey consisting of 24 questions. The responses were recorded on a five-point Likert scale, so that the date could be analyzed quantitatively. It took about fifteen minutes to complete, and it was administered by the teacher during class time. Another of the collection instruments was a semi-structured interview conducted with the teacher prior to the administration of the survey and with six students after the administration of the survey. The interview data was analyzed qualitatively using eleven codes which were aligned with the five categories identified in the Abeysekera and Dawson model, which is one of two frameworks that were used to analyze the results from the collected data (Muir & Geiger, 2016, p. 158-160).

Muir and Geiger (2016) used two frameworks to analyze the results from the data gathered. The first framework was the Four Pillars of FLIP, which outlines four features that every flipped classroom should have in order to have learning occur. The four features are a flexible environment, a shift in the learning culture, intentional content, and professional educators. Research has shown that three of these features are required in a traditional classroom setting as well. The major difference is the shift in learning culture, since the flipped classroom model requires a deliberate shift from a teacher-centered to a student-centered approach. The Four Pillars of FLIP framework was used to analyze the data in relation to the teacher's role in the classroom. The results showed that "other than the time and resources required to produce video resources, there were no concerns expressed or disadvantages identified by the teacher or

his students related to the implemented approach to the flipped classroom (Muir & Geiger, 2016, p. 167)." This study also did not find any resistance to the flipped classroom approach from the teacher or the students, even with the lack of pre-class preparation (Muir & Geiger, 2016).

The second framework used to analyze the results is a theoretical model by Abeyseker and Dawson. "The model recognizes the potential of the flipped classroom to instill a sense of competence, relatedness, and autonomy in students, leading to increased extrinsic and intrinsic motivation" (Muir & Geiger, 2016, p. 156). The ability to analyze student motivation was particularly important to the researchers in the study because the students were required to access learning resources outside of the school setting in the flipped classroom model. Muir and Geiger (2016) connected the students' motivation to complete these tasks with the students' overall learning. The results showed that only 60% of the students watched all of the available lesson videos, even through approximately 70% of the responses indicated that the videos supported their learning and 93% responded that they thought the online resources were helpful to their learning. These responses imply that while the majority of the students see value in the online videos as resources, some students still lack the motivation to watch and engage in every video. Muir and Geiger (2016) summarize their findings by stating the following,

> "While these findings are promising, it is important to acknowledge that the student took place in one 'extended mathematics' classroom and involved motivated students and their enthusiastic and conscientious teacher. It remains to be seen whether or not such an approach would be as effective if implemented with secondary mathematics classrooms in different contexts." (p. 169)

Conclusion

There seems to be a lot of research and literature available about the impact the flipped classroom model has on student engagement. Most of the research has shown an increase in student engagement when the flipped classroom approach is implemented in place of the traditional, lecture-discussion classroom approach. The research also indicates that there is no change in learning that is done by the students in a flipped classroom versus a traditional classroom. There are two-viewpoints that can be taken about this conclusion. This is either a good outcome because the students are not losing any learning by participating in a flipped classroom environment or a bad outcome because the students are more engaged in the flipped classroom setting, but they are not increasing their learning. The teachers and the students both seem to be more satisfied with the flipped classroom approach, but it still makes one wonder why the students are not increasing their academic performance. As DeSantis, Van Curen, Putsch, and Metzger (2015) state in their study, "Our data did not show that utilizing streaming videos as homework and class time as extending and refining sessions improved student learning outcomes" (p. 52). They go on to insist that the efficacy of the flipped classroom approach is mostly dependent on the skill and resources of the teachers that utilize it to meet the learning needs to their students. Results like these raise questions about the value of the various mechanisms that are embedded within the flipped classroom approach (DeSantis, et al., 2015).

The first mechanism are the online videos or resources used to deliver the academic instruction. The videos may be created by the classroom teacher or drawn together from an existing source such as Khan Academy or educational Youtube channels. The videos and resources used throughout the different studies are usually not assessed for quality. The study by de Araujo, et al. (2017) developed multiple ways to assess their resources based on the Mathematics Quality of Instruction (MQI) created by Learning Mathematics for Teaching

Project, Clark and Mayer's six principles of digital material design, and Moyer-Packenhame and Westenskow's dynamic virtual manipulatives. Their lesson materials could satisfy zero, one, two, or all three assessments. These assessments give the teachers or facilitators a way to evaluate the quality of their resources prior to implementing them in the classroom. All of the other surveys did not evaluate the quality of the resources used in their flipped classroom approaches. This made it difficult to compare the results of the studies (de Araujo et al., 2017).

Another limitation that was noted in many of the studies complete was the amount of time allotted for the research. Some studies spent as little as two weeks participating in the flipped classroom model (Chung & Hew, 2017). Most studies spent six to seven weeks gathering data while utilizing the flipped classroom approach. This may indicate that it was the change in instructional strategies that promoted more engagement from the students. The flipped classroom model was a new and exciting way of learning the mathematical material. There should be studies done over whole semesters or years of time to truly compare the flipped classroom approach with the traditional classroom approach.

Limited by the short time frame, many researchers had to focus their research on the classrooms while one topic was being covered. In the study done by Bhagat et al. (2016), the data was gathered while the students were learning the introduction to trigonometry functions. This is considered one of the easier topics in trigonometry. The results of the study could be impacted by the topic that was covered during the study. On the other hand, the study done by Kevin Clark (2015) was completed over the topic of solving systems of equations and inequalities. This is one of the more challenging topics that is covered in Algebra 1. The study done by Bhagat et al. (2016) showed an increase in student performance, while the study done by Clark (2015) showed no improvement in student performance. Both studies were completed

within seven weeks and showed an increase in student engagement. A study that covered a longer duration and a multitude of topics would be able give a more accurate picture of the impact the flipped classroom approach can have to engagement and academic performance (Bhagat et al., 2016 & Clark, 2015).

One aspect that is missing in the research are the types of modifications and strategies teachers have used to help improve student motivation and academic success while using the flipped classroom approach. A few studies, like the one completed by Chung Kwan Lo (2017), the teachers, researchers, or facilitators discuss how they made improvements or changes throughout their studies, but they were not able to provide data or results solely based on the changes that were made (p. 626). As Lo (2017) stated, "Not all practical problems that we encountered had been investigated and reported in the existing research" (p. 626). In future research, the changes should be noted and the data should be collected and analyzed prior to the changes and after the changes. This would allow the researchers to see the impact the changes made on the study (Lo, 2017).

The next step for research into the flipped classroom approach should be done over the possible modifications and strategies that teachers can make to improve student engagement and learning. The studies should be at least 2-3 months in length. The study done by Chung Kwan Lo and Khe Foon Hew (2017) has a detailed list of twelve recommended design changes and implementation techniques for a flipped classroom. The study also indicated the supporting resources for these modifications. However, the study itself does not adequately show or test the effectiveness that these changes had on the flipped classroom approach. Future studies should take this list and gather evidence to see which of these modifications truly make a difference. There could be three types of studies done. One type of study could cover the modifications

made to course planning, which could include predesigning instructional discussion questions for high-achieving and low-achieving students. The second type of study could cover the out of class learning modifications, such as should the videos be teacher created or gathered from other online resources. The third type of study could cover the in-class learning modifications, such as allowing the students to choose from various learning activities based on their needs (Lo & Hew, 2017).

The future research done on the flipped classroom approach needs to be focused. There are many broad studies out there that show the flipped classroom approach does increase student engagement and motivation, but the flipped classroom approach is not increasing student learning when compared to the traditional classroom approach. The studies should now focus of improving different aspects of the flipped classroom model to see if they can also improve student learning. With so many technology options now available to students and teachers, long-term research should also be done on the overall impact a flipped classroom approach can have when used in a multitude of various subjects throughout any given day. Teachers, parents, and students need to know if there is a limit to how much screen-time, videos, or flipped classroom instruction should be done in a given day. In short, there is a lot of research indicating that the flipped classroom approach can engage and motivate students in ways that the traditional classroom approach cannot, but more research is needed to find out more about the modifications and strategies that are used within the flipped classroom approach.

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