Spring 5-14-2021

The Effects That a Flipped Classroom has on Engagement and Academic Performance for High School Mathematics Students

Jordan Geraets
jordan.geraets@go.mnstate.edu

The Effects That a Flipped Classroom has on Engagement and Academic Performance for High School Mathematics Students

A Project Presented to the Graduate Faculty of

Minnesota State University Moorhead

By

Jordan Geraets

In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Curriculum and Instruction

April 2021

Moorhead, Minnesota

Abstract

Flipped classrooms continue to spark educator's attention and curiosity as an alternative to the traditional teaching and engagement in a classroom, especially during the time of a global pandemic. New, innovative technology has allowed for educators to be able to evolve their classrooms into new learning environments. Research into how flipped classrooms can impact mathematics classrooms and how students engage and perform differently than in a traditional mathematics classroom was expanded on in this study to determine what benefits there could be for students and how effective the teaching model can be in a class where students often struggle. As stated by Kwan Lo (2017), "changing the norms of a mathematics classroom is difficult, but if more studies are conducted in different school and social contexts, the research can support the work" (p.626). The purpose of the quantitative study was to find out if students prefer and perform better in a mathematics classroom that is more student-led than teacher-led in respects to how students learn, by exploring how a flipped classroom could engage them in this process. The underlying question that the research investigated in the study was, "how does the flipped classroom model affect the academic performance and engagement of secondary mathematics students?" There is a need to better understand on how this learning environment both affects students engagement and how it impacts students' performance in a mathematics class. The population of study was secondary students. The study provided understanding of how students could increase responsibility of their own learning at an earlier age than they are used to, while interacting more with their peers and the content in the classroom setting. A causal-comparative approach was used to analyze survey data from a unit in a geometry classroom on how students' felt their engagement and performance in a flipped mathematics classroom was compared to that in a traditional mathematics classroom.

DEDICATION

I am honored to dedicate this work to my parents who have always encouraged me to chase my dreams, wherever they may take me, and I am eternally grateful to be following in my mother's footsteps as an educator.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

In both education and the world, technology has been a constant change that people have had to adjust to and make the best use of. Technology has impacted the way that educators teach understanding and fluency of topics and encourage creativity from their students. Alsancak-Sirakaya and Ozdemir (2018) stated that, "in the 21st century, named as the information age, people are expected to be active in creating and interpreting knowledge rather than directly obtaining information presented and needing to be directed" (p.76). A growing concern in education has been about the ability to teach students to actively learn and problem solve while still having time to engage them in the process using technology. The flipped classroom has been a method of teaching that uses technology in the classroom to encourage both understanding in the topics and engagement from students through hands on activities that challenge them to think in different ways. The flipped classroom model is a method of teaching that enables students to watch prerecorded videos at home the night before class, and then when they get to class the next day, the time in the classroom is spent interacting with their peers through hands-on activities, problem solving, and discussions that are based on the lesson they learned. All while taking the material that they learned and going more in depth with their conversations; really challenging themselves to think outside the box. Throughout the researcher's time as a mathematics teacher, she has seen the advancement of technology and can see that this is an important issue that needs to be understood and addressed in the classroom. According to Avery et al. (2018), educators need to address the societal shifts and the speed of these changes in education by assuming new teaching and learning styles that align with 21st century ways of thinking, acting and being. The flipped classroom is one of these new styles of pedagogy that serves the needs of the modern student. Within mathematics, the flipped classroom is a method that teachers hope will alleviate students of some of the stress that the already difficult subject bestows upon them while trying to comprehend the material and get them to interact more with each other and the content in order to feel more confident and engaged in their own learning.

Brief Literature Review

The flipped classroom has been around for a while and even though many high school teachers haven't taken advantage of it, it is a method that can make great use of technology. It allows students to watch online video recordings of their lessons outside of the classroom and then time in the classroom is spent actively learning with activities, problem solving and discussions for interacting and expanding on the concepts learned (Bhagat et al., 2016; Fautch, 2015; Lo, 2017; Siguroardottir & Heijstra, 2020). Research suggested that the flipped teaching model can better engage students in the learning process and improve their academic performance compared to the traditional teaching model (Hodgson et al, 2017). Even though it is new to most students, the flipped model grabs students' attention in a way that traditional classrooms do not always have the time for. Spreading out the learning of the lesson and the interaction between activities and discussions allows students time to process material and extend their interest and curiosity about the topics. Activities and discussions in the classroom give students a chance to be hands on with the material and engage in a way that they would not have before. In a mathematics classroom, the flipped classroom can build a student's confidence and self-efficacy levels in a way that encourages them to take responsibility of their own learning, change their attitudes about mathematics, engage in the material, and strive for success (Capuno et al, 2019).

Academic performance in a mathematics classroom has been impacted by many factors but based on a study done by Sun and Wu (2016), students were able to improve their focus level and commitment to understanding content on their own in a flipped classroom model which influenced higher performance levels in the classroom. Students' attitudes towards math can really affect the progress they make in the class and the success that they have. Research has shown that educators need to better promote this effort from students by using teaching methods that constantly engage them and influence them to think outside the box (Ozkal, 2019). In addition to effort and engagement, student-teacher interactions can also affect how students interact in the mathematics classroom and with a flipped classroom model. Students are more apt to communicate with teachers using the increase in technology in the classroom and build those

positive relationships. Students are more willing to ask their questions that they have over email, online discussions, and Learning Management systems (like Schoology) whereas in the classroom, they were sometimes too afraid to ask (Avery et al., 2018). The videos make it possible for students to see their teachers outside of the classroom and makes it more of a relaxed atmosphere when first learning the content. In class activities and discussions make it possible for teachers to see how students are doing, give immediate feedback, and engage with them in a way that builds a stronger relationship and encourages more collaboration and conversations between student and teacher (Zilka et al., 2018).

Statement of the Problem

The research problem for the study was about how the traditional way of teaching in a classroom using lectures that take up most of the class time and little time for students to interact with the content and their classmates, seemed to be decreasing the amount of engagement and the performance level of mathematics students. The researcher researched the effects a flipped classroom has on the academic performance and engagement of secondary students in mathematics to see if this method of teaching will help students succeed more in class. They wanted to measure how students felt their engagement in the flipped mathematics classroom was compared to a traditional classroom and determine their thoughts on how their academic performance has been impacted. Researching the flipped classroom model and how it has affected math classrooms gave the researcher an idea of the impacts it has on students and whether it is worth incorporating into the classroom. This problem was chosen to be researched because if students had more time to discuss the content they had learned from the prerecorded videos and interact more with activities in class, then it could give students an opportunity to learn differently than they have in the past and give them more responsibility of their own learning. This new way of learning and teaching could have a positive impact on their performance in mathematics and their engagement with the content and others in class.

Purpose of the Study

Due to COVID19, teachers and schools have had to change their methods of teaching so that they can reach every student, every day, while still trying to engage and interact with them virtually. The

researcher wanted to investigate how a flipped classroom model could be a method that incorporates this way of learning while still improving student performance in math. They wanted to see if students do better when their learning is more student-led versus teacher-led. Student engagement in math was another affect that the researcher wanted to investigate in a flipped classroom because they believed students can always improve their engagement and that is a piece that has been found to be more difficult when students are learning virtually or in a hybrid model. The learning that students achieve could be affected by a flipped classroom model and the purpose for this study was to determine just that, what the effects are from students learning differently than they have had to in the past. The researcher had created prerecorded videos before for when they were absent from school, but they genuinely wanted students to learn this way for a longer period of time to see if there were benefits from students discovering more of their own learning and interacting more in the classroom. For reasons that are not COVID-19 related, the researcher wanted to find out the advancements that technology has taken in a short amount of time and how different methods of teaching could impact students' feelings about the content they are learning, since mathematics is not every student's favorite subject. By combining the two with the flipped classroom model, the researcher wanted to study how more time in the classroom to interact with the material and peers, versus just learning the content for the first time, would impact student motivation and engagement in a class that they had not always been engaged in before.

Research Question

How does the flipped classroom model affect the academic performance and engagement of secondary mathematics students?

Definition of Variables

Variable A. The independent variable of the study was the flipped classroom model. This model of teaching is where the direct instruction moves from the group learning environment in the classroom to the individual learning on their own. The classroom environment is transformed into a space where

interactive learning takes place and the educator guides students as they apply the concepts they have learned and engage creatively in the subject matter (The Flipped Learning Network, 2014).

Variable B. One of the dependent variables of the study was academic performance. "Academic performance represents the outcomes in the classroom that indicate the extent to which a person has accomplished specific goals that were the focus of lessons and activities in instructional environments, specifically in school, college and university" (Steinmayr et al., 2014).

Variable C. The other dependent variable of the study was student engagement. Engagement is the amount of attention, curiosity, interest, optimism, and passion that students show towards what they are learning. This also extends to the level of motivation students possess to learn, progress, and succeed in their own education (The Glossary of Education Reform, 2016).

Significance of the Study

This study was important for both the participants, who are the researcher's students, and for the researcher as the practitioner. It was important to the students because with this study, the researcher was able to learn about a different model of teaching to see if it would help the students understand and engage better in a mathematics classroom. Providing students with the ability to learn new study habits and have more responsibility of their own learning would hopefully grant them the opportunity to make more connections between concepts in math and practice having a better growth mindset of their mathematics ability (Lawson et al., 2019). The goal was to discover what a different learning model could do for the participants so that they can succeed more in and out of the classroom no matter if they are learning in a virtual setting or in a normal classroom setting. This study was important to the researcher because it would allow her to gain knowledge in the advancements of technology in a classroom setting and use that to build relationships with students as well as building a strong learning environment in the classroom. The researcher wanted to encourage the students to be more engaged with mathematics, and she thought that the study would give her the chance to enhance the students' learning

experience with knowing what type of engagement was needed and that the level of engagement was increased throughout each lesson, activity, and discussion they had in class (Hodgson et al., 2017). This study was also important for mathematics education because there have not been many studies completed on the flipped classroom and it being integrated into a high school math classroom. It had the possibility of showing the researcher and fellow math teachers what technology could do in the classroom and what effects there are for students doing more of their learning on their own.

Research Ethics

Permission and IRB Approval

In order to conduct this study, the researcher sought MSUM's Institutional Review Board (IRB) approval to ensure the ethical conduct of research involving human subjects (Mills & Gay, 2019). Likewise, authorization to conduct this study was sought from the school district where the research project took place (See Appendix A and B).

Informed Consent

Protection of human subjects participating in research was assured. Participant minors were informed of the purpose of the study via the Method of Assent (See Appendix C) that the researcher read to participants before the beginning of the study. Participants were aware that this study was conducted as part of the researcher's Master's Degree Program and that it would benefit his/her teaching practice. Informed consent means that the parents of participants were fully informed of the purpose and procedures of the study for which consent was sought and that parents understood and agree, in writing, to their child participating in the study. Confidentiality was protected using pseudonyms (e.g. Student 1) without the utilization of any identifying information. The choice to participate or withdraw at any time was outlined both, verbally and in writing.

Limitations

One limitation of the study was equity and access to technology. Since flipped classrooms require students to do more digital work at home when watching the prerecorded videos before class, any

student who did not have internet access or technology may have been at a higher risk of not completing the required tasks. The students were provided chrome books from the school but at certain times throughout the unit or year, the chrome book could have become broken or misplaced. Technology can also be unreliable, and students may have had difficulty watching the videos at home due to various reasons like connectivity issues or audio and visual damage to the technology. Socioeconomic factors could have played a role in this possible limitation and it could potentially impact less privileged students since they may have been the ones who didn't have access to necessary materials like internet or the inability to fix a chrome book if it was broken. In addition to technology access and issues, students also had limitations with the environment in which they were doing the work. Students were living either in split homes, commuting back and forth between divorced parents' homes or in single-parent homes. This provided a limitation because some students would forget their chrome book or charger at one parent's house, when they were staying with the other or they had to take more responsibility around the house and help out with younger siblings when their single parent was at work.

Conclusion

Recent literature and research have focused on the flipped classroom model being introduced more in classrooms at the university level versus the high school level. This study incorporated the flipped classroom model in a high school setting as well as within a mathematics classroom. The hope was to discover how students could learn better and how they engage with the content differently when they are having to learn more on their own outside of the classroom and interact more inside the classroom through activities and discussions. If the researcher understood and learned more about how students perform and get involved in a flipped classroom, then the researcher would feel more confident in the decisions on how to teach to the students and what learning models to use that would best impact their future learning. In the next chapter, there will be a literature review of the current literature that relates to the flipped classroom model of teaching, student engagement in these settings, and the impacts they have on students' academic performance.

CHAPTER 2
LITERATURE REVIEW

Introduction

Different teaching models have been successful throughout education that allow for students to interact, engage, and achieve more than they have before. It is the job of an educator to continually search for these new teaching models and do what it best for the students in their classrooms each school year. Technology has contributed to new teaching models that have the possibility of better educating students so that they are learning and interacting with the content throughout the whole lesson (Alsancak-Sirakaya & Ozdemir, 2018). The flipped model of teaching has been one of the models that educators and researchers have studied more recently. It has been described by educators as a method that uses prerecorded videos, either produced by educators themselves or other educators, to teach the concepts of the lesson to students while they are at home the night before class. Then when students go to class the next day, they interact in the classroom by engaging in discussions and activities that challenge students to investigate the topics of the lesson further. Educators and students have had varying viewpoints on the flipped classroom model and how effective it is with educating students (Van Sickle, 2016). These different viewpoints provided the researcher with plenty of sources to gather information from. Though there may have been plenty of sources for flipped classrooms in general, there were not that many studies that had been done in a secondary mathematics classroom. Therefore, it was important for the researcher to look further into the effects that the flipped classroom model can have on student engagement and how they perform academically in a secondary mathematics classroom. The researcher tried a variety of search terms to gather this information from sources that studied the various themes that the researcher wanted to study relating to mathematics and how students engage and perform in the classroom. The literature review below synthesized research and studies that had been completed on the flipped classroom and their effects on students' learning.

Flipped Classroom

Advantages

The flipped classroom is an innovative way to learn in the world of education and technology. It takes the traditional format of in-class lectures and transforms them into short online course recordings to be watched outside of class, and then the time spent in the classroom is used for active learning through interactive activities, guided problem solving, and discussions (Bhagat et al., 2016; Fautch, 2015; Lo, 2017; Siguroardottir & Heijstra, 2020). In mathematics, there has been limited research to date on flipped classrooms. Bhagat el al. (2016) stated that for years researchers have highly recommended the use of technology across the mathematics curriculum so that students can achieve positive results in their learning and understanding of mathematics as well as challenge themselves on how mathematics strategies are used outside the classroom. The flipped teaching model is one way of being able to use technology in the mathematics curriculum. Avery et al. (2018) argued that it allowed for students to learn at their own pace and be more responsible for their own learning with some students classifying this as a "sink or swim" type of learning style. Students usually do not show much responsibility for their own learning, but they have faced the challenge and understand that they must keep their efforts up and not get behind. The flipped classroom has various types of learning that takes place every day such as hands-on activities that entice kinesthetic learners, videos that help visual learners, as well as many others. These different types of learning are not necessarily a part of the traditional classroom, where students claim they get bored more often due to the repetition of the same type of lectures and learning that takes place every day (Avery et al., 2018; Sun & Wu, 2016). Students make more connections between concepts in the flipped classroom model and it is allowing them to productively struggle in making these connections while practicing towards having a growth mindset about their ability and intelligence in math (Lawson et al., 2019).

Disadvantages

Incorporating the flipped classroom model into what was a traditional classroom can come with challenges, though. Miles and Foggett (2016) explained that changing the way a class is taught from the traditional lecture format to the flipped or blended learning format challenges the relevance of the lectures and classroom interactions in which researchers once thought was the most effective environment for learning. The changing nature of the delivery of the lesson creates a need for students to adopt different study patterns that they have not had before due to having to incorporate learning outside of the classroom (Bouilheres et al, 2020; Miles & Foggett, 2016). Students feel like they must teach themselves the content, versus learning it from a teacher while in a structured environment in a classroom. Bouilheres et al. (2020) also noted that technology within learning may disadvantage certain student populations due to their lack of access to appropriate means of technology outside of school. With a higher responsibility of their own learning and being able to determine their own approaches to learning the content, which some may find as positive developments, it still must be considered that the impacts these changes are making on student workload may be ineffective to their own learning (Miles & Foggett, 2016).

Academic Performance

Influencing Factors

Academic performance in a classroom can be produced from many factors. Some factors that may influence this performance may be the effect of class sizes, others may be students' attitudes towards the specific content, student-teacher relationships, teaching models, or how engaging the content is (Ndidi & Effiong, 2020). Each of these factors can influence academic performance of a student in a mathematics classroom. A study done by Sun and Wu (2016) in a university physics class showed results similar to other research with flipped classrooms in that students were able to enhance their focus level

and commitment to understanding content in the flipped classroom model which promoted higher performance levels in the class. Students' attitudes towards the content that was being taught, specifically in math, and how much they were engaged impacted how well students learned and were willing to put effort into their success (Ozkal, 2019).

Self-efficacy

Self-efficacy has a big impact on how students perform in mathematics. Self-efficacy is defined as the beliefs one has about their capabilities to specifically produce and influence events that will affect parts of their lives (Abu-Hilal & Al Abed, 2019). Studies done in mathematics have demonstrated that self-efficacy does positively and significantly affect academic performance in the classroom (Tasdemir, 2016). Ozkal's study (2019) also declared that in lower secondary math classrooms, students' self-efficacy beliefs of their learning and understanding in mathematics was found to predict and affect mathematic achievement. In the flipped classroom model, this confidence and motivation that students gain from their self-efficacy beliefs is important for them to utilize. The change in students' learning environments and having to adjust to new study habits, interactions, and responsibilities of their own learning can have a positive impact on their academic performance (Alsancak-Sirakaya & Ozdemir, 2018). Though there are students whose academic performance can benefit from these changes, there are also students who do not do well with having a reasonable amount of responsibility or adjusting to change and could feel negative impacts of the flipped classroom.

Engagement

Engagement in classes at school is a necessity for students to feel success and to be able to develop their learning. Engagement is the act of students participating in their learning environments by staying interested and curious in the topics being taught in order to extend their learning in that designated area (Abu-Hilal & Al Abed, 2019; Avery et al., 2018; Irvine, 2019; Ozkal, 2019; Poysa et al., 2019). In the flipped classroom, the prerecorded videos and the in-class activities need to be engaging for students

to benefit from the teaching model. If engagement from the videos and activities does not happen, then disengagement will incur, and students will feel overwhelmed by responsibility for their own learning and their inability to stay coherent with the understanding of it. Ozkal (2019) mentioned that there are three types of engagement in the classroom: behavior engagement which refers to attending class and participating in activities, affective/emotional engagement which is the willingness to actually get involved with activities in the classroom and cognitive engagement refers to making cognitive efforts towards actually learning the material in the activities and being willing to advance that knowledge. In the classroom, students can contain none, some, or all these types of engagement and it is the job of educators to enhance the students' learning experience so that they improve their engagement level throughout each lesson and activity (Hodgson et al., 2017). According to Hodgson et al (2017), students who participated in a flipped classroom tended to stay more cognitively engaged in lessons and learning versus those in a traditional classroom.

Abu-Hilal and Al Abed (2019) concluded from their research that if teachers wanted their students to be engaged in learning mathematics, they must equip them with skills that will proclaim high confidence and self-efficacy. If students do not have the confidence in learning mathematics, they will not stay engaged with the content through the initial learning stages or through in-class activities. According to many researchers, increased student engagement is one of the by-products of a flipped classroom (Hodgson et al., 2017). For many teachers, that is an appeal of the flipped teaching model because it gives students a chance to engage differently with the concepts and learning activities that they would not have in a traditional teaching model classroom. More innovative instructional material, activities, and short, memorable videos can contribute towards student engagement and change student attitudes about the mathematics classroom and flipped classroom model for the better (Capuno et al., 2019; Sammel et al., 2018).

Student-Teacher Interaction

Online learning, blended learning and flipped classrooms are taking advantage of the increased number of educational technologies that are available and creating various learning opportunities and environments for all students through them. With an increase in educational technologies, Avery et al. (2018) found more ways of communication between students and teachers as well as building positive relationships. The videos gave students an idea of their teacher's life outside of school. The videos can be created in various locations which allows students to see their teacher as an actual person and not just a teacher in a classroom. In-class activities allows for teachers to observe students, gain knowledge of their strengths and their needs, which therefore transfers to a stronger relationship with students. McCallum et al. (2015) agreed that the flipped classroom has changed the dynamics of teacher-student communication and made it more technologically available. In classrooms that are completely online, more discussions are had outside the classroom and these teachers tend to be more available to respond to students in a quick manner due to not having students in the classroom while their other students are learning the content online (Avery et al, 2018). By having more time to answer questions in the classroom or online in an online format, these frequent interactions between teacher and student were found to be more strongly associated with student satisfaction with their school experience.

Zilka et al. (2018) pointed out that teacher presence and interaction encourage a climate in the classroom of collaboration, cooperation, and personal conversations between teacher and students in both virtual and blended courses. Hegarty and Thompson (2019) argued that teachers who were actively present using mobile technology influenced student engagement and its immediate effects such as achievement, satisfaction, and retention. This contributed to the idea that interactions between students and their teachers is the core activity in education (Irvine, 2020; Sun & Wu, 2016). Teacher practices must be intentional on how the classroom environment is set up with respect to frequent access to communication between student and teacher. Emotional support from teachers, especially in younger secondary schools, has also been shown to be positively related to students' situational engagement (Poysa et al, 2019). This support can come from an emotional connection by getting to know the student,

showing warmth and trust, mutual respect, and teachers responding to students' social and emotional needs. Students are more likely to engage in interaction with teachers to seek help when they know they have emotional support from them. Even though all students need this support in order to interact, Sengul et al. (2019) believed that younger students were more influenced by these relationships with teachers because older students have their peers to connect with and are influenced easier by them. After doing research on this matter with online learning, Park and Kim (2020) found that their results confirmed that even with secondary level students, using interactive communication tools can increase the presence of student-teacher communication which positively affects students learning experiences in the classroom such as engagement and satisfaction.

Theoretical Framework

A theory that focuses on engagement and student-led learning is the Constructivist Learning Theory. The Constructivist Learning Theory, which has been adapted by many theorists over the past century like Dewey, Bruner, Vygotsky and Piaget, is about how knowledge is constructed by human interaction with the world around them and with each other (Xu & Shi, 2018). Student interaction, collaboration, and engagement are prominent in the constructivist theory of learning. Humans construct knowledge by their experiences and environments around them (Olusegun, 2015). Constructing new knowledge comes from a student's prior and existing knowledge and when they are engaged, they are applying this knowledge to real-world experiences and learning from them by making hypothesis, testing them out, and drawing conclusions. The Constructivist Learning Theory is about understanding how something works and functions versus reinventing it (Olusegun, 2015). The actions of learning for oneself relates to how the flipped classroom is a student-centered learning method with the teacher playing the role of the facilitator when the teacher helps guide students through the learning environment (Xu & Shi, 2018). The theory also aligned with engagement and performance in the mathematics classroom since both are impacted by the interaction of students amongst themselves, the content, and activities in the classroom that will challenge them to think further about the topics in math. Actively

learning and exploring content in a flipped classroom through these activities and discussions allowed for students the ability to self-direct their own learning and discover their knowledge on the topic. Since math is a cumulative subject where one lesson topic impacts others, the constructivist theory corresponds well with it since students use their already existing knowledge to help construct new knowledge for themselves. Even though the theorists all have had an impact on what the constructivist learning theory is today, Vygotsky rejected what others thought on how learning is separated from the social context and said that learning happens through social interactions that stimulate the learning and engagement of the student (Liu & Matthews, 2005). Engagement in self-directed learning is what drives the flipped classroom and how students can academically perform better knowing that they control how they learn the content.

Research Question

Based on prior literature and the researcher's interest on how to help students stay engaged in a mathematics classroom, it led her to want to research the following question, how does a flipped classroom affect the academic performance and engagement of secondary mathematics students?

Conclusion

Education is ever-changing and it produces learning environments that allow educators to adjust their teaching to any student in the classroom. Technology is another factor to education that has created new innovations and opportunities for students to learn effectively and at their own pace. Within both areas, education and technology, the research helped show how the flipped classroom has contributed to new learning opportunities for students to interact, engage, and challenge themselves with the independence of their own learning. Though this may be new and challenging for some students, there have been many positive effects and attributes to incorporating the flipped teaching model into the classroom. Because this learning method can throw a huge twist into the learning routine and environment of students, researchers should investigate how to maximize its benefits for the greatest

number of learners. Then, educators can use those results to analyze the effects that this model has on how students learn and interact in the classroom. How engagement, performance, and relationships in the classroom will be affected are just a couple of the factors that need to be researched further for educators and students to incorporate this method of teaching into their classrooms.

CHAPTER 3
METHODS

Introduction

Students are growing up in a world where they have always had some sort of technology in their homes, classrooms, or everyday life. A lot of teaching still today, though, uses very minimal technology which does not always motivate or encourage students while they are at school. With there being little research on the flipped classroom model and its implementation into a mathematics classroom, there needs to be more research performed to determine possible effects that a flipped classroom could have on students' engagement and academic performance in a mathematics classroom. In this study, the researcher taught half the participants, who were students, in a flipped classroom model and the other half in a traditional classroom model. The study completed in this action research shows how a flipped classroom model can affect the engagement of students in the classroom and their academic performance by having more student-centered learning outside the classroom using pre-recorded lesson videos, and more engaging activities inside the classroom that push and challenge students' problem solving and communication skills to a whole new level. The researcher chose a quantitative survey to gather data because the researcher saw mostly qualitative interviews or surveys and she also thought it would be hard to gather quantitative data from a performance test when comparing two different classes, so she felt that she should use a quantitative survey to better understand the qualitative results that other studies have already reported.

Research Question

How does the flipped classroom model affect the engagement and academic performance of secondary mathematics students?

Research Design

The research design that was selected for the action research was the causal-comparative research design. In addition to the study already being an action research design where the focus of the study was

on a specific situation in a classroom and the participants' active involvement in the study was observed, the causal-comparative design allowed for the exploration of the cause or consequences of certain differences that exist amongst the intervention and comparison groups in the study (Fraenkel et al., 2015). This design allowed for comparisons between teaching models to show the effects that one has and how those effects could be different from one another. Action Research was chosen because the researcher wanted to obtain information on how to increase engagement and performance in a mathematics classroom. In a mathematics classroom, participants tend to get disengaged very quickly and easily if it is a subject in school that they are not interested in so action research would allow the researcher to explore the problem in the classroom and try to determine a solution. The causal-comparative design was chosen by the researcher because it allowed for them to study one geometry class that had the flipped classroom model implemented and determine if there were improvements in student engagement and academic performance compared to the traditional classroom model being taught in another geometry class. The participants were assigned to their classrooms naturally at the start of the year, the researcher did not decide which group they went to. By comparing these two groups, the researcher hoped that the effects that the flipped classroom model would have on a mathematics classroom would be clearly observed and determined, so that changes could be made to encourage an increase in engagement and academic performance in the classroom. This study was a quantitative study that used a survey to collect data, then the researcher calculated the mean of various questions answered on the surveys and compared participant perceptions of their own engagement and academic performance in the flipped mathematics classroom.

Setting

The setting of the study took place in an urban high school in central Minnesota. The school district is in a town with a population of about 13,700 people, where some students come from rural communities just outside of town. Some of the largest industries responsible for the town's economy are manufacturing, health care, and accommodation and food services. The town is known for its location

along the Mississippi River where some students live in the township across the river and travel across it to and from school.

The school district consists of 5 schools: one high school grades 9th-12th, one middle school consisting of grades 6th-8th, and 3 elementary schools from grades Pre-K to 5th. The high school is located close to the middle of town and not far from many businesses, a major interstate, and the Mississippi River. As of 2020, the high school had 1,203 students enrolled in grades 9-12. The majority of students at the school are white, making up 85.6% of the student population, with the other percentages coming from students who are Hispanic or Latino, 8.5%, Asian, 2.3%, Black or African-American, 1.3%, American Indian or Alaska Native, 0.3%, and 1.9% of students classify as two or more races. There is 16.6% of the student body at the high school who receive Free or Reduced meals which includes breakfast and lunch, along with 12.1% of students who are in Special education, 1.9% of students are English Learners and 0.7% of students are classified as homeless (Minnesota Department of Education, 2020).

Participants

The participants of each group in the study were from two geometry classes taught by the same teacher consisting of a total of about 60 students. One class was taught using the flipped classroom model for the study and the other class was taught from the more traditional model. These participants were in their mathematics class in the middle of the day either from 9:45-10:25am or 11:35am-12:15pm and consisted of 23.3 % of 9th grade students and 76.7% 10th grade students ranging in age from 14-16 years old. The participants were split evenly based on gender, where 50% of the participants were female and 50% male. As for ethnicity of the participants, 87% were White, 6.66% were Asian, 3.33% were Black, and 3.33% were Hispanic. Of the 60 students, 2-3 students were receiving special education services and one student was receiving English Learning services. Quite a few students were living in either split homes, commuting back and forth between divorced parents' homes, or in single-parent homes.

Sampling

A purposive sampling was done for this study. Since the participants are the researcher's students and in her geometry classes, all of them were conveniently available to the researcher to participate in the study which makes it a purposive sampling. The research done on the effects that the flipped classroom model had on secondary mathematics students was directed towards already knowing the students in the classroom, how they were engaged and how they performed in mathematics.

Instrumentation

The instrument that was used for data collection on student engagement and academic performance was a survey (See Appendix D). The researcher developed questions for the survey by thinking about different ways students can be engaged in a mathematics classroom based on the teaching model that they received. The survey contained questions that were developed based on Ozkal's research (2019), Skinner et al. (2008) and Rotgans and Schmitdt's (2011) research on behavioral, emotional, and cognitive engagements. Communication and participation in class discussions amongst peers or the teacher, is classified as a way that students can engage in the classroom, as well as how interested they are in the material that they are learning. Other questions on the survey were developed based on how students perceived their own academic performance in the classroom. These questions would pertain to how students felt their understanding was for each week of the study, how certain factors within the classroom may or may not have impacted their performance that week, and how well they followed the procedures of watching the lesson videos before class to prepare for class the next day. The Likert scale was used for the survey, with a 5 being "strongly agree" and a 1 being "strongly disagree." Each question asked students to decide how they agreed with the statement based on their engagement, learning and understanding in the geometry classroom during that week and unit.

Data Collection

The data from the survey (Appendix D) was collected on a Google Form due to students being in different learning formats: full-time at school, hybrid learners and full distance learners. The survey was distributed through Schoology that students are enrolled in for each class that they have, and then the survey link was provided for students to take after the quiz and test for that unit. Collecting and analyzing data each week from the results of each participant was easier in this format and allowed for more participants to partake in the survey digitally if they were to be at home distance learning that day.

Data Analysis

After collecting data on the survey (Appendix D), the researcher summarized it by marking down the tallies and totals from each class of participants based on the number they selected from strongly agree to strongly disagree on the Likert Scale to each question asked. Then the mean scores of each question were computed and compared between the intervention group (flipped classroom model) and the comparison group (traditional teaching model). The mean for each question or group of questions were compared not only between the intervention and comparison group, but also separated and compared based on the units covered before and after the intervention was applied. This analysis was done each time that the survey was distributed and completed by the students so that the researcher could compare the data between each chapter based on how students felt their engagement and performance in the geometry classroom was going.

Research Question(s) and System Alignment

The table below (Table 1) provides a description of the alignment between the study Research Question(s) and the methods used in this study to ensure that all variables of study have been accounted for adequately.

Table 1

Research Question Alignment

Research Question	Variable	Design	Instrument	Validity & Reliability	Technique (e.g., interview)	Source
How does the flipped classroom model affect the engagement and academic performance of secondary mathematics students?	The dependent variables of the study were the engagement of the students and student academic performance. The independent variable for the study was the Flipped Classroom Model.	This study followed a causal-comparative design along with action research. The study compared student engagement and academic performance of students who were taught mathematics in a flipped classroom model versus those who were taught in the traditional classroom model.	Survey on students' thoughts of their own engagement and academic performance in the mathematics classroom using a Likert Scale (Appendix D)	Videos for the flipped classroom model were short as well as lessons done while in class. Activities, amount of homework, and time spent to complete tests stayed the same between the groups to ensure validity. The questionnaires were all completed online so that students who switched between in class learning and distance learning during the study still completed what they had been familiar with the whole year.	Students completed a survey that asked about their thoughts of their engagement and academic performance in the math classroom on a Likert Scale. The scores for each student were collected on a Google Form and compared into categories like gender, grade level, and class they were in. The mean values and a t-test were calculated so that it could be determined whether the students' opinions were significantly different between classes.	Total of 60 participants in 9th and 10th grade. Their age ranges were from 14-16 years old and were in two different geometry classes.

Procedures

The study took place over the course of 3 weeks. At the beginning of the study, participants were given a survey on how their engagement was in the last geometry unit when all participants were being taught using the traditional classroom model with the lesson being taught in class and most of the homework completed outside of class. After the survey was completed, the new unit was started with one class being taught using the flipped classroom model (the intervention group) with prerecorded lesson videos watched outside of class, and activities, problem solving, and homework done in the classroom and the other class had continued being taught using the traditional teaching model (the comparison group). The process for how both groups were being taught continued each day during the three-week unit, unless it was a review day. The survey was given each week of the unit throughout the study when participants were taking either the quiz or the test on the geometry material being covered in the unit.

Each day the videos for the intervention group were around 10-15 minutes long as well as the lessons taught in class to the comparison group. The participants would then be able to ask questions amongst each other or with the researcher and be given time in class to discuss and work through concepts together for 20 minutes and then get individual work time for the remainder of the class time while being Work time and discussion time was longer for the intervention group than the comparison group, due to the time that was spent teaching the lesson in class to participants in the comparison group. There was a quiz in the middle of the 3-week unit, to gather information on how participants were doing so far in the unit and whether there needed to be changes made to the discussions in class to allow for more guided practice through the material. The second survey was given at this time. After the three-week period, there was a unit test on the geometry material covered to determine what the participants understood from the unit and the final survey was given to the participants to determine their thoughts on their engagement and performance during the whole unit.

Ethical Considerations

To make sure that the study was ethical, the researcher took necessary measures to guarantee the wellbeing of all participants. Informed consent was required and given by all parents of participants. Parents signed a consent form before the study began to ensure that they were rightfully informed about the study, its purpose, and how the participants information would be kept confidential from the study. All videos were prerecorded from the school to ensure that the researcher had a private, educational environment when teaching the lesson. For participants who watched videos at home for the flipped classroom model, the researcher and school district made sure that students had Wi-Fi hotspots or places to go to watch the videos with an internet connection. Scores for the math tests and results of the survey were either stored on Schoology or Excel for participants and/or parents to view, but no information was recorded that would identify students with the study. For the whole study, if there were more stressed participants due to the new teaching model, having to stay caught up at home, or various other reasons, the researcher made sure that participants had access to help either with extra one-on-one google meets with the researcher, access to their counselor's, a social worker, or other participants (study groups) to turn to for help.

Conclusion

The importance of new teaching models is higher than ever before due to the pandemic that we are facing. Educators need to continuously understand where their students are at in their classroom and in their learning, so that these teaching models can be used to have the most impact in engagement, motivation, and academic performance. As for the math classroom, research has shown that students feel the most effect from communication amongst peers and teachers while in the classroom and being able to ask questions right away when they get stuck versus having to wait until the next day where they may forget or give up all together by that time (Poysa et al, 2019). The flipped classroom is just one model that has allowed for this based on previous research. This chapter provided details on how this study was conducted in a secondary mathematics classroom, what data was collected and how the flipped classroom

model was implemented into a geometry classroom. The next chapter will include the results of the study and an analysis of the data that was collected by the researcher.

CHAPTER 4

RESULTS

The 2020-2021 school year started with many unknowns of what was to come due to a global pandemic and it continued with the same unknowns throughout the year. Teachers and students started the year in a hybrid learning model where the students were in person 2 days a week and distance learning the other three, then they went to full distance learning, then back to hybrid, and then ended out the year fully back in person exactly a year from when it all started. No one in education could have predicted what the year would have been like. Even with the change in teaching and learning models, my action research was still able to be performed. Technology enabled teachers to be able to google meet with their students and use prerecorded lesson videos for students to watch while they were at home. The purpose of my action research was to investigate the effects that a flipped classroom model could have on a high school geometry student's engagement and performance in class. Students took a survey that examined the effects of the flipped classroom model and their preferences on having a more student-led learning environment versus teacher-led.

Data Collection

High school freshman and sophomore geometry students took a survey on the effects that a flipped classroom could have on their engagement and performance. The survey (Appendix D) asked students to select a number 1-5 from strongly disagree to strongly agree on the Likert Scale for each question. A one on the Likert Scale was strongly disagree, two was somewhat disagree, a three was neither agree of disagree, a four was somewhat agree, and a five was strongly agree. Data from the survey was completed by the students on a Google Form so that if they were learning from home or if they were at school, they had access to the survey through our Schoology page on their school issued Chromebook. The link was shared to students the morning that they were to take the survey, at the beginning and end of the unit. This allowed for data to be collected on how students felt their performance and engagement were in math class at the beginning and end of a new unit. Data from the

surveys were received from students who were in the flipped classroom (intervention group) and the traditional classroom (comparison group) to compare the beginning and end of a unit but also compare amongst the two groups.

Results

How does the flipped classroom model affect the engagement and academic performance of secondary mathematics students?

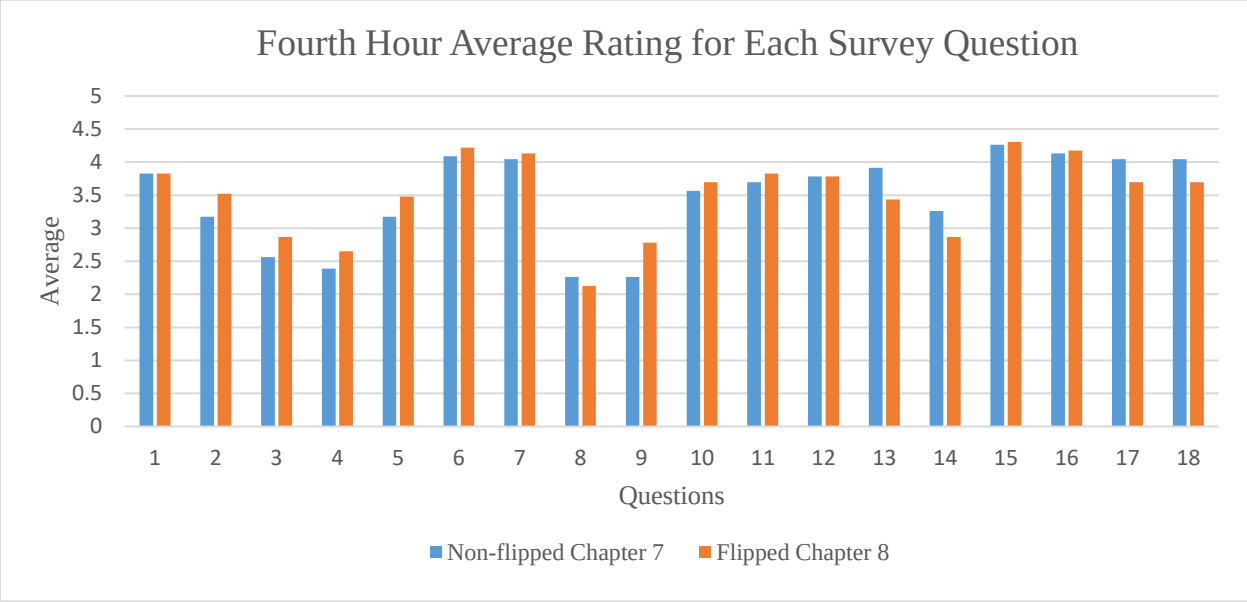
There were two different geometry classrooms that were surveyed, out of a total of six that are at the high school, on how they felt their engagement and performances were in math class. The students in fourth hour geometry were participating in the flipped classroom and the students in fifth hour geometry were taught using the traditional classroom model. Fourth hour geometry consisted of 23 students surveyed and fifth hour had 22 students surveyed. There were 9 students in fourth hour and 8 in fifth hour that chose to not be a part of the study. The first survey was administered after students finished their chapter 7 test in geometry and before they started chapter 8. The second survey was administered after the students finished their chapter 8 test in geometry. The chapter 7 unit was on similarity and the chapter 8 unit was on right triangles. After the chapter 7 test, the survey was taken by both hours to determine how students originally felt about their engagement and performance in geometry in the traditional classroom model. Then after the chapter 8 test, the survey was taken again by both hours to compare flipped classroom learning and the traditional classroom learning of the same unit.

The first set of data that was observed was the data comparing fourth hour when it was in the traditional classroom model for chapter 7 versus the flipped classroom for chapter 8. When fourth hour was in the traditional model, seven percent of the questions were answered with a strongly disagree, fourteen percent of the questions were answered with a somewhat disagree, thirty percent were answered as neither agree or disagree, thirty-four percent answered as somewhat agree, and fifteen percent were answered as strongly agree. After the flipped classroom was initiated for fourth hour in chapter 8, five percent of the questions were answered with a strongly disagree, thirteen percent were answered as

somewhat disagree, twenty-nine percent answered as neither agree or disagree, thirty-eight percent were answered as somewhat agree, and fifteen percent with strongly agree. The averages for each question on the survey for before and after the flipped classroom model was applied in fourth hour can be seen in Figure 1.

Figure 1

Fourth Hour Average Rating for Each Survey Question



Note. This figure represents the average scores, on the Likert Scale, that the students gave each question on the survey. The traditional or non-flipped classroom model, represented in blue, included 23 students' opinions on what they thought about their engagement, understanding and performance. The flipped classroom model, represented in orange, included the same 23 students for the following chapter using the same survey questions.

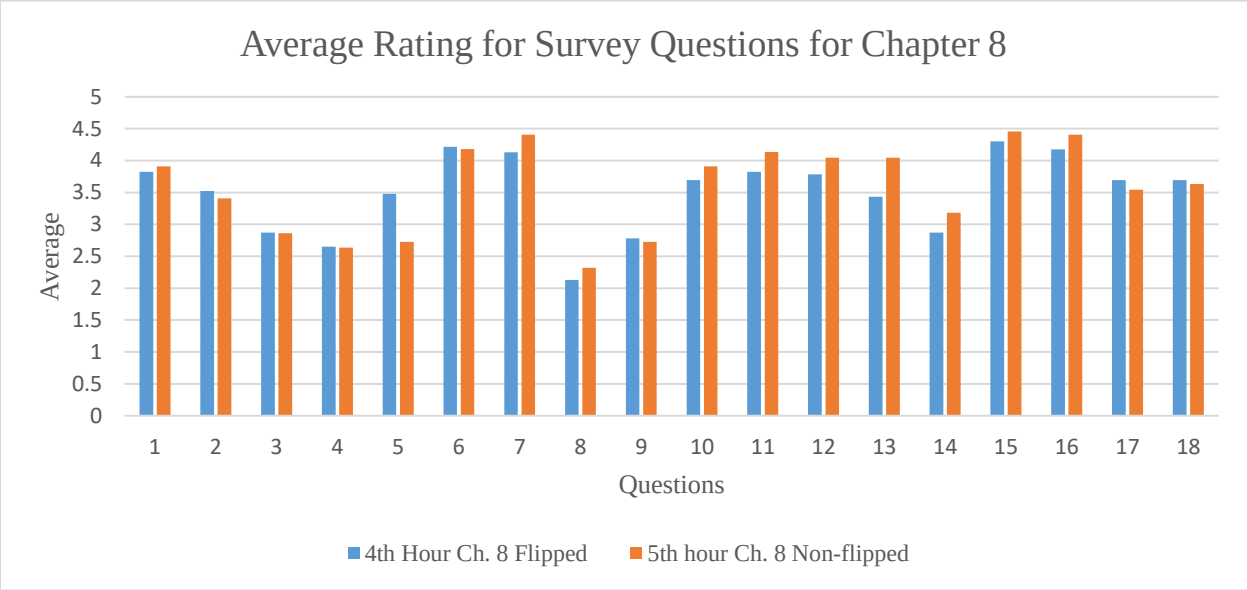
Figure 1 shows the average scores that students gave each question on the survey from strongly disagree (1) to strongly agree (5). The same twenty-three students were surveyed at the end of both chapter 7 and chapter 8 based on what they thought about learning in the traditional classroom model versus the flipped classroom. The numbers along the bottom of the figure show the question number

from the survey and the numbers along the left side of the figure represent the average scores that students answered for each question on the survey.

The second set of data that was observed was the data between the flipped classroom for fourth hour after completing chapter 8 and the traditional classroom for fifth hour after completing the same chapter. There were 23 students in the flipped classroom and 22 students in the fifth hour traditional classroom. This data compared how students felt about the same chapter 8 content being taught whether they were in the flipped classroom or the traditional classroom. As stated above for the flipped classroom, five percent of the questions were answered with a strongly disagree, thirteen percent were answered as somewhat disagree, twenty-nine percent answered as neither agree or disagree, thirty-eight percent were answered as somewhat agree, and fifteen percent with strongly agree. For fifth hour when the students were taught chapter 8 with the traditional classroom model, four percent of questions were answered as strongly disagree, ten percent were answered as somewhat disagree, twenty-nine percent were answered as neither agree or disagree, thirty-seven percent were answered as somewhat agree, and twenty percent of the questions were answered as strongly agree. The averages for each question on the survey for fourth hour when they were taught with the flipped classroom model and fifth hour in the traditional classroom model can be seen in Figure 2.

Figure 2

Average Rating for Survey Questions for Chapter 8



Note. This figure represents the average scores, on the Likert Scale, that the students gave each question on the survey. The flipped classroom model, represented in blue, included 23 students' opinions on what they thought about their engagement, understanding and performance in chapter 8. The traditional or non-flipped classroom model, represented in orange, included 22 students from fifth hour using the same survey questions for the same chapter.

Figure 2 shows the average scores that students gave each question on the survey from strongly disagree (1) to strongly agree (5). Twenty-three students were surveyed at the end of chapter 8 when they were taught using the flipped classroom and twenty-two students were surveyed at the end of the same chapter after they were taught with the traditional classroom model. The numbers along the bottom of the figure show the question number from the survey and the numbers along the left side of the figure represent the average scores that students answered for each question on the survey.

The third set of data that was observed were specific to certain questions in the survey that pertained to students' opinions on their engagement in geometry class and compared amongst the fourth

hour students from chapter 7 when they were taught using the traditional classroom model and the same students in chapter 8 when they were taught using the flipped classroom model. From the survey, questions 2, 3, 4, 10, 11, and 12 were directly asking about the students' perception of their engagement in geometry class during the unit. Interaction with others and interaction with the content were both classified as engagement in the study. For example, question two stated, "I talked about math with other students and/or the teacher in class throughout the unit." Another example is from question 10, "Geometry is challenging for me, but I try to engage in it the most that I can." The rest of the questions can be found in Appendix D. The percentages for the rating received for each of these engagement questions can be seen in Table 2.

Table 2

Engagement Questions for Fourth Hour

Question	Chapter 7 Traditional Survey Rating %					Chapter 8 Flipped Survey Rating %				
	1	2	3	4	5	1	2	3	4	5
Question 2	13.04	17.39	17.39	43.48	8.7	0	21.74	13.04	56.52	8.7
Question 3	13.04	39.13	26.09	21.74	0	4.35	26.09	47.83	21.74	0
Question 4	17.39	43.48	34.78	0	4.35	8.7	30.43	52.17	4.35	4.35
Question 10	0	0	43.48	56.52	0	0	0	30.43	69.57	0
Question 11	0	0	30.43	69.57	0	0	0	39.13	39.13	21.74
Question 12	0	0	39.13	43.48	17.39	0	0	34.78	52.17	13.04

Note. The numbers shown in the table represent the percentage of students who rated each engagement question based on the Likert Scale, where a 1 represents strongly disagree up to a 5 that represents strongly agree. The percentages are out of a total of 23 students in fourth hour for both the traditional classroom in chapter 7 and the flipped classroom in chapter 8.

The fourth set of data that was observed were specific to certain questions in the survey that pertained to students' opinions on their performance in geometry class and compared amongst the fourth hour students from chapter 7 when they were taught using the traditional classroom model and the same students in chapter 8 when they were taught using the flipped classroom model. From the survey, questions 1, 6, 13, 15, 16, 17, and 18 were directly asking about the students' perception of their performance in geometry class during the given unit. Performance in the survey was classified as a student's effort and how they felt they performed with the math during class. For example, question one stated, "I worked as hard as I could during this unit in geometry." Another example is from question 17, "I feel I perform better in math when the teacher is teaching the lesson in front of me in class and then I get some time to engage and start homework while at school." The rest of the questions can be found in Appendix D. The percentages for the rating received for each of these performance questions can be seen in Table 3.

Table 3

Performance Questions for Fourth Hour

Question	Chapter 7 Traditional Survey Rating %					Chapter 8 Flipped Survey Rating %				
	1	2	3	4	5	1	2	3	4	5
Question 1	0	4.35	39.13	26.09	30.43	0	4.35	34.78	34.78	26.09
Question 6	0	8.7	13.04	39.13	39.13	0	0	17.39	43.48	39.13
Question 13	0	0	39.13	30.43	30.43	0	4.35	47.83	26.09	17.39
Question 15	0	4.35	13.04	34.78	47.83	0	0	21.74	26.09	52.17
Question 16	0	0	13.04	60.87	26.09	0	0	4.35	73.91	21.74
Question 17	0	0	17.39	60.87	21.74	0	4.35	26.09	65.22	4.35
Question 18	0	13.04	60.87	26.09	0	0	17.39	21.74	52.17	8.7

Note. The numbers shown in the table represent the percentage of students who rated each performance question based on the Likert Scale, where a 1 represents strongly disagree up to a 5 that represents strongly agree. The percentages are out of a total of 23 students in fourth hour for both the traditional classroom in chapter 7 and the flipped classroom in chapter 8.

The next set of data that was observed were specific to certain questions in the survey that pertained to students' opinions on their engagement in geometry class, but this data compared the survey results from the 23 students in fourth hour after chapter 8 when they were taught using the flipped classroom model and the results from the 22 students in fifth hour after chapter 8 who were being taught using the traditional classroom model. From the survey, questions 2, 3, 4, 10, 11, and 12 were directly asking about the students' perception of their engagement in geometry class during the unit. Interaction with others and interaction with the content were both classified as engagement in the study. Like above, the questions can be found in Appendix D. The percentages for the rating received for each of these engagement questions can be seen in Table 4.

Table 4

Engagement Questions for Fourth Hour Flipped and Fifth Hour Traditional Classes

Question	Chapter 8 Traditional Survey Rating %					Chapter 8 Flipped Survey Rating %				
	1	2	3	4	5	1	2	3	4	5
Question 2	4.55	13.64	31.82	36.36	13.64	0	21.74	13.04	56.52	8.7
Question 3	9.09	22.73	40.91	27.27	0	4.35	26.09	47.83	21.74	0
Question 4	9.09	27.27	54.55	9.09	0	8.7	30.43	52.17	4.35	4.35
Question 10	0	0	22.73	63.64	13.64	0	0	30.43	69.57	0
Question 11	0	0	4.55	77.27	18.18	0	0	39.13	39.13	21.74
Question 12	0	0	18.18	59.09	22.73	0	0	34.78	52.17	13.04

Note. The numbers shown in the table represent the percentage of students who rated each engagement question based on the Likert Scale, where a 1 represents strongly disagree up to a 5 that represents strongly agree. The percentages from the fifth hour traditional classroom are out of a total of 22 students and the percentages from the fourth hour flipped classroom are out of a total of 23 students. Both classes were surveyed after chapter 8.

The last set of data that was observed were specific to certain questions in the survey that pertained to students' opinions on their performance in geometry class and compared between the fifth hour traditional classroom after chapter 8 and the fourth hour flipped classroom after chapter 8. The fifth hour class had 22 students surveyed and the fourth hour class had 23 students surveyed. From the survey, questions 1, 6, 13, 15, 16, 17, and 18 were directly asking about the students' perception of their performance in geometry class during the unit. Performance in the survey was classified as a student's effort and how they felt they performed with the math during class. As stated in data gathered above, the questions can be found in Appendix D. The performance questions found in the survey relate both effort that students portrayed during the unit and their overall feelings on how they felt their performance was with the content that they learned. The percentages for the rating received for each of these performance questions can be seen in Table 5.

Table 5

Performance Questions for Fourth Hour Flipped and Fifth Hour Traditional Classes

Question	Chapter 8 Traditional Survey Rating %					Chapter 8 Flipped Survey Rating %				
	1	2	3	4	5	1	2	3	4	5
Question 1	0	0	40.91	27.27	31.82	0	4.35	34.78	34.78	26.09
Question 6	0	0	22.73	36.36	39.13	0	0	17.39	43.48	39.13
Question 13	0	4.55	13.64	54.55	27.27	0	4.35	47.83	26.09	17.39
Question 15	0	0	9.09	36.36	54.55	0	0	21.74	26.09	52.17
Question 16	0	0	4.55	50	45.45	0	0	4.35	73.91	21.74
Question 17	0	0	27.27	50	22.73	0	4.35	26.09	65.22	4.35
Question 18	0	4.55	36.36	50	9.09	0	17.39	21.74	52.17	8.7

Note. The numbers shown in the table represent the percentage of students who rated each performance question based on the Likert Scale, where a 1 represents strongly disagree up to a 5 that represents strongly agree. The percentages from the fifth hour traditional classroom are out of a total of 22 students and the percentages from the fourth hour flipped classroom are out of a total of 23 students. Both classes were surveyed after chapter 8.

The class average and standard deviations on engagement and performance on the entire survey before and after fourth hour learned in the flipped classroom model were also compared by performing a t-test. The t-tests gave results on the class mean and standard deviation on engagement and performance questions while fourth hour learned in the traditional model as well as when they learned in the flipped classroom. These results came from the selected engagement questions, as listed above, and the selected performance questions that Table 2 and 3 compare with percentages. Fourth hour had twenty-three students complete the survey and the mean values and standard deviations that were compared in Table 6 below.

Table 6

Results of T-Test on 4th Hour Engagement and Performance Questions

Questions	4th Hour Traditional		4th Hour Flipped		t-Stat	P-value	t-Critical Value
	M	SD	M	SD			
Engagement	3.1957	0.5962	3.3915	0.5041	-3.6532	0.0147	2.5706
Performance	4.0433	0.1420	3.9069	0.3275	1.4742	0.1909	2.4469

Note. For each of the twenty-three participants, their scores on the survey were taken and then averaged amongst the whole class. Table 6 shows the mean and standard deviation values of the fourth hour traditional, and fourth hour flipped classroom pertaining to the engagement and performance questions on the survey. The t-tests were Paired Two Sample for Means tests with an Alpha of 0.05. This type of t-test was used since the same class was being surveyed both before and after the flipped classroom was applied. The t-Stat represents the test statistic being compared, the p-value is the probability value that tells how likely that data could occur under the null hypothesis, and the t-Critical value is a critical value on the test distribution that is compared to the test statistic.

Data Analysis

Engagement

As I analyzed the data between fourth hour when it was traditional in chapter 7 and when it was flipped in chapter 8, I noticed in Figure 1 that the flipped classroom had slightly higher averages in the first group of questions in the survey. A lot of the first group of questions came from the engagement of students, so Figure 1 revealed that the flipped classroom engages the same group of students over two different units slightly better than the traditional classroom. Table 2 also coincided with this conclusion. In Table 2, the results revealed that in the statements that revolved around engagement in the survey, the ratings for the traditional classroom had more students rating lower scores or disagreeing with each

statement whereas the flipped classroom had students rating a little higher for each statement that pertained to the engagement of students. Students agreed more with the engagement statements in the flipped classroom than when they disagreed with the same statements from the chapter before when they were being taught in a traditional classroom.

These results from the fourth hour geometry class, in different learning models, did provide results that I expected. I expected that the flipped classroom would be the preference for students to gain more engagement in a mathematics classroom because for most students, math usually has been a class that is a lot about pencil, paper and repetition of algorithms and calculations instead of discussions and interactions that would engage more students more often. Many researchers have also concluded that increased student engagement is one of the by-products of a flipped classroom (Hodgson et al., 2017). Zilka et al. (2018) pointed out that more interactions amongst students and teachers throughout a class can encourage a climate in the classroom of collaboration, cooperation, and personal conversations between teacher and students in both virtual and blended courses. This was shown in the results since the students were in a hybrid model when the study was performed. Similar results were seen in Figure 2 and Table 4. Between the fourth hour flipped classroom and the fifth hour traditional classroom, there looked to be a small difference, if any, between the averages on the survey questions and when the table looked further into the statements about engagement. The engagement statements seemed to show that students felt about the same between models, with a couple of questions showing a slight increase from the traditional to flipped classroom. In figure 2, the survey question that had the largest difference between the flipped and traditional classrooms was question number five, “I found the topics or activities we did during this unit interesting.” This question was not specifically categorized into an engagement or performance question, but I found it interesting because students who found the topics more interesting were those in the flipped classroom and could relate to how they felt the flipped classroom environment was more interesting for them to learn in than the traditional classroom.

Table 6 shows results from the t-test that compared the mean score and standard deviation of the entire class from the engagement questions on the survey. The results coincide with the results from the figures and tables before it. In Table 6, the null hypothesis was that the means between fourth hour before and after the flipped classroom model were equal. In the table, we can see that the test statistic for the engagement was -3.6532 which is less than the critical value of -2.5706 (two-tailed), therefore we can reject the null hypothesis and say that the observed difference between the means of fourth hour during the traditional learning model and after the flipped classroom model do have a significant difference. From the table, we also see that the P-value of 0.0147 is less than the Alpha value which was 0.05, which is another data statistic that concludes that there is a significant difference between the means of both groups.

Performance

Data from the fourth hour traditional classroom and the fourth hour flipped classroom also showed a slight difference, or about the same, in averages for questions that pertained to performance. In Figure 1, the traditional classroom had about the same or slightly higher averages in the last group of questions in the survey. The last questions in the survey were related to the students' performance in the geometry classroom during the given unit, so based on Figure 1, this revealed that the same group of students perform slightly better or about the same in the traditional classroom than they do in the flipped classroom. Table 3 revealed similar results to Figure 1, there were less ratings of a 5, or strongly agree, on statements that related to performance in the geometry classroom for the flipped classroom versus when the students were taught in a traditional classroom. There were some questions though, that did increase the number of ratings of a 2 or 3 to a 4 from traditional to flipped, so that did give mixed results with performance since some performance statements had an increase and some had a decrease from the traditional to flipped classroom for the fourth hour geometry class.

Having mixed results or similar results for performance in a traditional and flipped classroom was also a result that I expected. Students can tend to forget to watch videos ahead of time and then while

they are in class, they get less interaction time than expected because they are busy trying to catch up on what they did not do the night before. This then can affect their performance and effort in class. The number of times that this occurred was not measured, but the same students who usually forgot to do homework at home also forgot to watch the video. Also, students may forget the content they learned when they come to class the next day, so the interactive activities that could be happening in class the next day may not be as efficient if students do not remember what they learned the night before. Some studies that were performed by Bouilheres et al. (2020) and Miles and Foggett (2016) coincide with this idea where students may not perform as well in a flipped classroom than a traditional classroom due to the increase in responsibility of their own learning versus learning the content directly from the teacher in class. Similar results were seen in Figure 2 and Table 5. Between the fourth hour flipped classroom and the fifth hour traditional classroom, there was not a significant difference between the averages on the survey questions and when the table looked further into the statements about performance. The performance statements were similar, with the students stating that they felt they performed about the same between the different models in chapter 8. There were more ratings of "strongly agree" in the traditional classroom than the flipped classroom, though, so like the previous figure and tables, students think they slightly performed better in the traditional classroom.

Table 6 shows results from the t-test that compared the mean score and standard deviation of the entire class from the performance questions on the survey. The results coincide with the results from the previous figures and tables. In Table 6, the null hypothesis was that the means between fourth hour before and after the flipped classroom model were equal. In the table, we can see that the test statistic for the performance questions was 1.4742 which is between the absolute values of the critical value 2.4469 (two-tailed), therefore we would fail to reject the null hypothesis and say that the observed difference between the means on the performance questions in both models is not convincing enough to say that the average student's performance differs significantly. From the table, we also see that the P-value of 0.1909 is greater than the Alpha value of 0.05, which is another statistic that helps conclude that there is

not enough evidence to say there is a significant difference between the means of the traditional and flipped classrooms.

Due to the global pandemic, students were in different models of learning throughout the study, with most the students in the hybrid learning model but also having some students learning full distance, so this could have been a factor that may have affected the data collection. The smaller number of participants was due to these reasons as well. Originally, I planned on having sixty participants in the study but due to distant learners and students who did not turn in their consent forms, the participant number went down to forty-five. Students who were distance, and those who fluctuated back and forth due to quarantine, were not always physically at school to participate in some activities that were more hands-on versus activities that were technology based so that made it difficult to make sure students were engaging in the activities during the flipped classroom model. The survey ended up being a good tool for this study because students had access to it digitally through our Schoology page and were easily able to fill it out. If I did the study again, I probably would add an additional tool to help with clarifying the results better, either with a performance test or by journaling each day to reflect on how I was perceiving students doing in the flipped or traditional classroom models in relation to their engagement and performance.

Conclusions

COVID-19 forced many schools to transform their curriculum from full in person curriculum, to curriculum that was compatible with distance and hybrid learning since students would be switching back and forth between these methods throughout the school year. Even with the many unknowns of the school year with how and where the students would be learning, it seemed like a good time for this study to be performed on how the flipped classroom model could affect the engagement and performance of high school geometry students. The results do have some uncertainty to them due to the changing of delivery methods, but the results did still compare similarly to previous research that the flipped classroom would positively impact how students engaged and performed in the mathematics classroom.

Students do still have a slight preference to receiving the instruction at school versus over prerecorded videos when initially trying to understand and perform well in the classroom. The pandemic disrupted both the students' and teachers' daily routines in the last year, but through all of it still came the need for making connections and interacting with others in the classroom and that was fostered through both the traditional and flipped classroom models.

CHAPTER 5
IMPLICATIONS FOR PRACTICE

Action Plan

After research performed over the last year and applying the flipped classroom to my geometry class for a couple weeks, I plan to continue implementing the flipped classroom in some form in the years to come. I think interchanging between the flipped classroom model and the traditional classroom model starting from the beginning of the year will allow students to get used to the two methods and know what is expected of them. Our school district has Chromebooks provided to each student in grades 6-12, and internet availability either at home or through the school, which gives us all the opportunities for the flipped classroom to be successful in the future even when we are fully back at school. Prior to the study, I had used the flipped classroom model for when I was absent from school or if a student was absent, but now going forward students have all the capabilities and videos available to them so they could ultimately learn at their own pace throughout each unit or the entire school year while engaging in classroom discussions and activities while at school. It will give students a chance to circle back to content that they were struggling with, and re-watch or pause videos as they prepare and work through assessments.

From the study, I did learn that students do need training on the skills that it requires to learn more on their own through the flipped classroom. As I plan for implanting it in the next school years to come, I would make sure that students were trained on studying skills so that they feel more adequate to engage with the flipped classroom lessons and really feel successful with it. Parents and administration will be able to see how students are applying what they are learning on a more day to day bases due to the increase in discussions and activities that will be performed in class. With the effort shown from students, parents and administration will hopefully start to see less of the stress that has come from math classes in the past and more excitement on how they learn math going forward. For upper-level math courses, especially those that are college or AP level, I could see the flipped classroom impacting how students advance through those classes and get a feel for what college course are like while still at school

getting guidance and help from their peers and teachers. The flipped classroom has the potential of being a great advantage to the higher-level math courses as students strive and what to keep learning the content on their own while getting a chance to see how the math is used and being more hands-on with it while in class.

Plan for Sharing

Especially after the year that school districts have had with distance learning along with the technology that we have access to, the flipped classroom is something that can be implemented at every level of our school district. I have been trying to encourage our upper-level math courses to implement the flipped classroom more into their teaching going into the next school year due to the research that I found in higher level math courses and the implementation of my own study. Students have the capability of learning on their own, if we teach them necessary skills beforehand, so I think starting with the upper-level math courses will allow for students to engage more with harder content that they don't always get to visualize how it's related to the real world or why they are learning it to begin with. The math department at the high school meets on a semi-monthly bases, on top of our daily communications we already have, so I plan on bringing my results to our next meeting to share with them and encourage them to incorporate more of the strategies they used this year, with their hybrid and distance learners, into their future classes. I think starting on sharing my results with my department will give my colleagues a chance to prepare for next school year and how they want to engage their students more while hopefully we are all fully back at school. After sharing my results with my colleagues, I will share my news with our administration. The head principal used to be a math teacher, and he was intrigued by the topic of flipped classroom, so sharing my results with him might allow him to get a better idea of how to possibly implement the flipped classroom into other departments as well.

REFERENCES

Abu-Hilal, M. & Al Abed, A. (2019). Relations among engagement, self-efficacy, and anxiety in mathematics among Omani students. *Electronic Journal of Research in Educational Psychology, 17(*2), 241-266.

Alsancak-Sirakaya, D. & Ozdemir, S. (2018). The effect of a flipped classroom model on academic achievement, self-directed learning readiness, motivation and retention. *Malaysian Online Journal of Educational Technology, 6(*1), 76-91.

Avery, K., Huggan, C., & Preston, J. P. (2018). The flipped classroom: High school students' engagement through 21st century learning. *In Education, 24*(1), 4-21.

Bhagat, K. K., Chang, C. N., & Chang, C. Y. (2016). The Impact of the Flipped Classroom on Mathematics Concept Learning in High School. *Educational Technology & Society, 19*(3), 134–142.

Bouilheres, F., McDonald, S., Nikhoma, C., & Jandug-Montera, L. (2020). Defining student learning experience through blended learning. *Education and Information Technologies,* 1-20. https://doi.org/10.1007/s10639-020-10100-y

Capuno, R., Necesario, R., Etcuban, J.O., Espina, R., Padillo, G., & Manguilimotan, R. (2019). Attitudes, study habits, and academic performance of junior high school students in mathematics. *International Electronic Journal of Mathematics Education, 14(*3), 547-561. https://doi.org/10.29333/iejme/5768

Fautch, J. M. (2015). The flipped classroom for teaching organic chemistry in small classes: Is it effective? *Chemistry Education Research and Practice, 16,* 179-186.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2015). *How to design and evaluate research in education.* New York, NY: McGraw Hill Education.

Hegarty, B. & Thompson, M. (2019). A teacher's influence on student engagement: Using smartphones for creating vocational assessment eportfolios. *Journal of Information Technology Education: Research, 18*, 113-159.

Hodgson, T. R., Cunningham, A., McGee, D., Kinne, L., & Murphy, T. J. (2017). Assessing behavioral engagement in flipped and non-flipped mathematics classrooms: Teacher abilities and other potential factors. *International Journal of Education in Mathematics, Science, and Technology, 5(*4), 248-261. Doi: 10.18404/ijemst.296538

Irvine, J. (2020). Positively influencing student engagement and attitude in mathematics through an instructional intervention using reform mathematics principles. *Journal of Education and Learning, 9*(2), 48-75.

Lawson, A. P., Davis Caylor R., & Son, J. Y. (2019). Not All Flipped Classes Are the Same: Using Learning Science to Design Flipped Classrooms. *Journal of the Scholarship of Teaching and Learning, 19*(5), 77–104. doi: 10.14434/josotl.v19i5.25856

Liu, C. H., & Matthews, R. (2005). Vygotsky's philosophy: Constructivism and its criticisms examined. *International Education Journal, 6*(3), 386-399.

Lo, C. K. (2017). Examining the flipped classroom through action research. *The Mathematics Teacher, 110(*8), 624-627. doi: 10.5951/mathteacher.110.8.0624

McCallum, S., Schultz, J., Sellke, K., & Spartz, J. (2015). An examination of the flipped classroom approach on college student academic involvement. *International Journal of Teaching and Learning in Higher Education, 27*(1), 42-55.

Miles, C. A., & Foggett, K. (2016). Supporting our students to achieve academic success in the unfamiliar world of flipped and blended classrooms. *Journal of University Teaching & Learning Practice, 13*(4), 1-14.

Minnesota Department of Education. (2020, November 29). *Minnesota report card.* https://rc.education.mn.gov/#demographics/orgId--10882020000__p--9

Ndidi, M. A., & Effiong, I. E. (2020). Influence of classroom environment on senior secondary school students' academic achievement in mathematics in Calabar Nigeria. *Educational Research and Reviews, 15(*8), 495-503.

Ozkal, N. (2019). Relationships between self-efficacy beliefs, engagement and academic performance in math lessons. *Cypriot Journal of Educational Science, 14(*2), 190-200.

Park, C. & Kim, D. (2020). Perception of instructor presence and its effects on learning experience in online classes. *Journal of Information Technology Education: Research, 19*, 475-488.

Poysa, S., Vasalampi, K., Muotka, J., Lerkkanen, M., Poikkeus, A. & Nurmi, J. (2019). Teacher-student interaction and lower secondary school students' situational engagement. *British Journal of Educational Psychology*, *89*(2), 374-392.

Rotgans, J. I., & Schmidt, H. G. (2011). Cognitive engagement in the problem-based learning classroom. *Advances in Health Sciences Education, 16,* 465-479. https://doi.org/10.1007/s10459-011-9272-9

Sammel, A., Townend, G., & Kanasa, H. (2018). Hidden expectations behind the promise of the flipped classroom. *College Teaching, 66(*2), 49-59. http://doi.org/10.1080/87567555.2016.1189392

Sengul, O., Zhang, X., & Leroux, A. J. (2019). A multi-level analysis of students' teacher and family relationships on academic achievement in schools. *International Journal of Educatioonal Methodology, 5*(1), 117-133. http://dx.doi.org/10.12973/ijem.5.1.131

Sigurðardóttir, M. S., & Heijstra, T. M. (2020). Mixed approaches to learning in the flipped classroom: How students approach the learning environment. *The Canadian Journal for the Scholarship of Teaching and Learning, 11*(1). https://doi.org/10.5206/cjsotl-rcacea.2020.1.8098

Skinner, E., Marchand, G., Furrer, C., & Kindermann, T. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic? *Journal of Educational Psychology, 100*(4), 765-781. https://doi.org/10.1037/a0012840

Sun, J. & Wu, Y. (2016). Analysis of learning achievement and teacher-student interactions in flipped and conventional classrooms. *International Review of Research in Open and Distributed Learning, 17*(1), 79-99.

Tasdemir, C. (2016). An examination of vocational school students' self-efficacy beliefs in mathematics and of their achievement levels. *Educational Research and Reviews, 11(*8), 804-811. doi:10.5897/ERR2016.2777

Van Sickle, J. (2016) Discrepancies between student perception and achievement of learning outcomes in a flipped classroom. *Journal of the Scholarship of Teaching and Learning*, *16*(2), 29-38. doi: 10.14434/josotl.v16i2.19216

Xu, Z. & Shi, Y. (2018). Application of constructivist theory in flipped classroom-take college English teaching as a case study. *Theory and Practice in Language Studies, 8*(7), 880-887. http://dx.doi.org/10.17507/tpls.0807.21

Zilka, G. C., Cohen, R., & Rahimi, I. D. (2018). Teacher presence and social presence in virtual and blended courses. *Journal of Information Technology Education: Research, 17*(1), 103-126.

Appendix A

IRB Approval

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

DATE:	February 1, 2021
TO:	Ximena Suarez-Sousa, Principal Investigator Jordan Geraets, Co-Investigator
FROM:	Lisa Karch, Chair Minnesota State University Moorhead IRB
ACTION:	**DETERMINATION OF EXEMPT STATUS**
PROJECT TITLE:	[1709821-1] The Effects That a Flipped Classroom has on Engagement and Academic Performance for High School Mathematics Students
SUBMISSION TYPE:	New Project
DECISION DATE:	January 27, 2021

Thank you for your submission of New Project materials for this project. The Minnesota State University Moorhead IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations under 45 CFR 46.104.

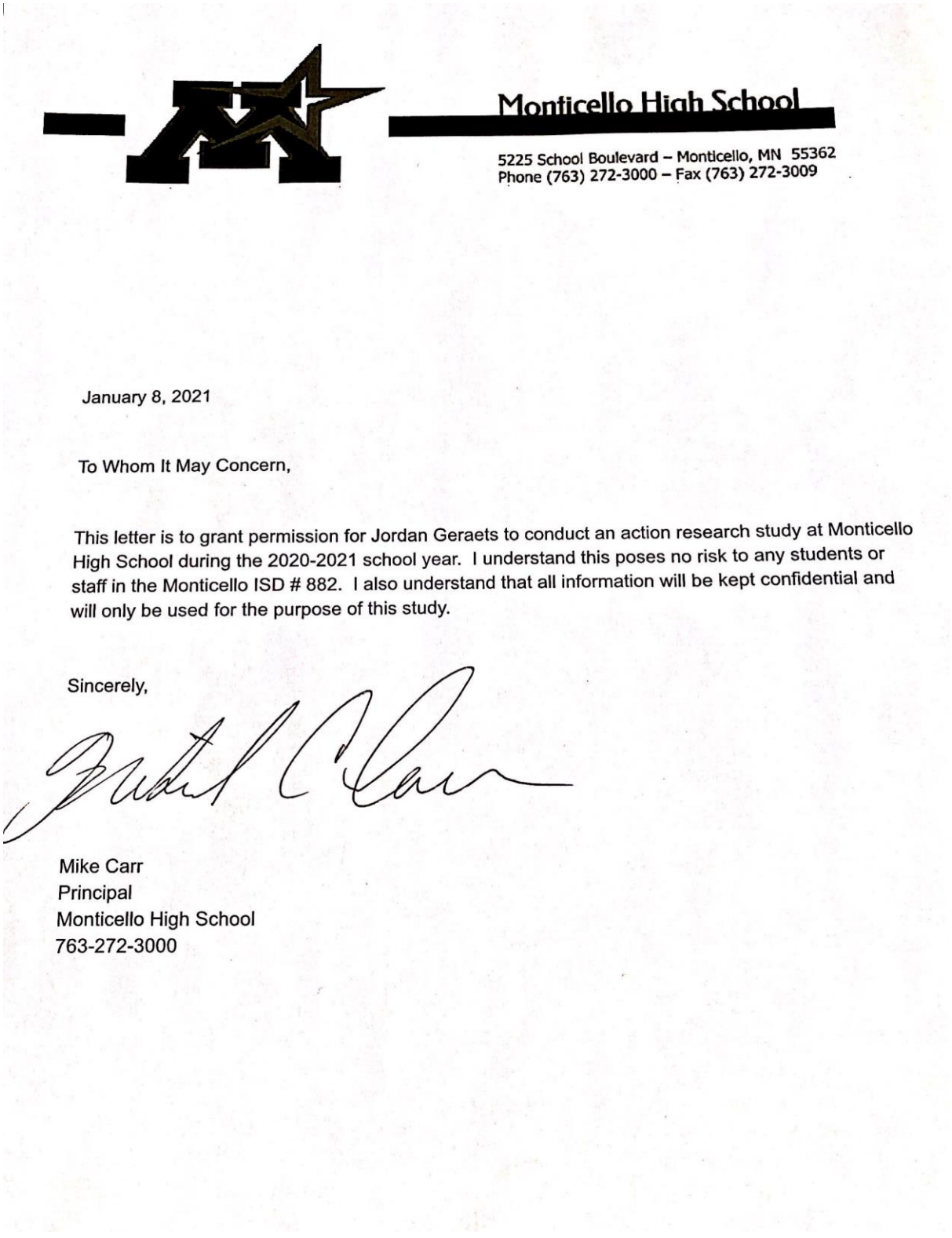
We will retain a copy of this correspondence within our records.

If you have any questions, please contact the Minnesota State University Moorhead IRB. Please include your project title and reference number in all correspondence with this committee.

This letter has been issued in accordance with all applicable regulations, and a copy is retained within Minnesota State University Moorhead's records.

Appendix B

Administration Authorization



Monticello High School

5225 School Boulevard – Monticello, MN 55362
Phone (763) 272-3000 – Fax (763) 272-3009

January 8, 2021

To Whom It May Concern,

This letter is to grant permission for Jordan Geraets to conduct an action research study at Monticello High School during the 2020-2021 school year. I understand this poses no risk to any students or staff in the Monticello ISD # 882. I also understand that all information will be kept confidential and will only be used for the purpose of this study.

Sincerely,

Mike Carr
Principal
Monticello High School
763-272-3000

Appendix C

Letter of Consent

Dear Parent or Guardian,

Your child has been invited to participate in research to see if the flipped teaching model will help students with their academic performance and engagement in the math classroom.

Your child was selected for this study because he/she is in my geometry class, where the study is being conducted. If you decide for your child to participate, please know that your child will be asked to complete typical math lessons, activities, and homework just like they would normally, the content is just going to be delivered to them in a different way. Listed below are a couple of the objectives your child will be asked to do during the unit that the study will take place.

1. Students will watch a 6-10 minute lesson video and take notes the night before class. When in class, students will be doing interactive activities, warm-ups, and/or check-ins with the teacher to check for understanding of the topic. They will also utilize time to work on practice problems.
2. Students will be given a survey at the end of the unit to see how well they felt they understood the content when delivered in the flipped model and how well they were engaged.

The purpose of this research is to determine if the flipped classroom model can help students better engage and perform in their math class. The data and information gathered will be kept confidential. All individual information will be recorded under coded numbers and not the participant's name. Teachers normally adjust their teaching methods in the classroom to see what may help improve students' performance and engagement in the classroom without the need of consent, but since this is for my Master's degree, consent is needed. Students can choose at any time to not participate in the study without any consequences or penalties, participation is optional.

Contact: If you have any questions, you can contact me at jordan.geraets@monticello.k12.mn.us or 763-272-3036 . You may also contact the Principal Investigator, Ximena Suarez-Sousa, Department of Leadership and Learning at MSUM, at suarez@mnstate.edu or 707-630-0941. Any questions about your rights may be directed to Dr. Lisa I. Karch, Chair of MSUM Institutional Research Board, at irb@mnstate.edu, or 218-477-2699.

Agreement: The purpose and nature of this research have been sufficiently explained and I agree to allow my child to participate in this study. I understand that I am free to withdraw at any time.

In signing this agreement, I also affirm that I am at least 18 years of age or older.

_____
Name of Student (Print)

_____ _____
Signature of Parent or Guardian Date

_____ _____
Signature of Investigator Date

Appendix D

Engagement and Performance in Mathematics Survey (on Google Forms)

Circle your gender: Male or Female

Circle your grade: 9^{th} or 10^{th}

Circle your geometry hour: 4^{th} or 5^{th}

On a scale of 1-5, select how you felt about the following prompts: 1= Strongly Disagree, 2= Somewhat Disagree, 3= Neither Disagree or Agree, 4= Somewhat Agree, 5= Strongly Agree

	Strongly Disagree	Somewhat Disagree	Neither disagree or agree	Somewhat Agree	Strongly Agree
I worked as hard as I could during this unit in geometry.	1	2	3	4	5
I talked about math with other students and/or the teacher in class throughout the unit.	1	2	3	4	5
I shared my ideas and thoughts with students in geometry class.	1	2	3	4	5
Math class was engaging for me most of the week/unit.	1	2	3	4	5
I found the topics/activities we did during this unit interesting.	1	2	3	4	5
I understood the topics we covered in geometry this week	1	2	3	4	5
I tried to learn as much as I could in geometry class this week.	1	2	3	4	5
Geometry is interesting to me.	1	2	3	4	5
I like solving problems in geometry class.	1	2	3	4	5
I did a lot of critical thinking in geometry this week/unit.	1	2	3	4	5
Geometry is challenging for me, but I try to engage in it the most that I can.	1	2	3	4	5
I feel like hands on activities help me understand math better.	1	2	3	4	5
I felt my performance in geometry this week/unit was good.	1	2	3	4	5
I get distracted easily when learning geometry.	1	2	3	4	5

I want to complete the geometry work and activities to the best of my ability.	1	2	3	4	5
When I am engaged in class, I feel I do better on the assignments and tests.	1	2	3	4	5
I feel I perform better in math when the teacher is teaching the lesson in front of me in class and then I get some time to start homework while at school.	1	2	3	4	5
I feel I perform better in math when I can learn the material ahead of time and then get time in class to engage and work through the content.	1	2	3	4	5

If there is anything else you would like to mention about how you felt math class went during this unit, please write it below: