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Mathematics teacher's experience with flipped learning : a phenomenographic approach

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Mathematics Teacher's Experience with Flipped Learning: A Phenomenographic Approach

by

Sandra Speller

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Curriculum & Instruction

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An Abstract of

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Flipped learning has gain status in the education community in recent years. However, a review of earlier studies shows that the relationship associated with types of schools, teacher experiences and outcome spaces has still remained unchartered territory and there has been little discussion related to flipped classroom environment. To fill this gap, this phenomenographic study explored the experiences of flipped learning among six mathematics teachers from Northwest Ohio and southeast Michigan. Data was collected from classroom observations and individual teacher interviews. Their scope of experience with flipped learning has enabled me to compare strategies and approaches and develop an understanding of how the teacher identifies which approaches appear to work and under which circumstances. Conclusively, an examination of the six mathematics teachers gave an insight into what makes flipped learning effective both for the teacher as a means of "experiencing" the phenomenon of flipped learning and for the researcher to "experience" how the teacher experiences the phenomenon. This study is

extending perspectives of research for flipped learning in mathematics education through the experiences of mathematics teachers.

In memory of my parents, Rev. Wiley Meeks, Jr. & Mary Alice Meeks

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Chapter One

Introduction

Education is one field that is constantly changing and adapting to meet the needs of students. As students' learning habits change, educational instruction must adapt to match those learning habits. Lage, Platt and Treglia (2000) introduced the idea of using technology to "flip" a traditional classroom environment. In this method known as the "flipped classroom," "inverted classroom," or "reverse instruction," among others, what is traditionally done in class is switched with what is traditionally done for homework. The flipped classroom encompasses any use of technology, including the Internet, to leverage the learning in the classroom, so teachers can spend more time interacting with students instead of lecturing. This is most commonly being done using teacher created videos that students view outside of class time.

Instead of students listening to a lecture during class and going home to do homework, students watch video lectures and complete what has traditionally been known as homework in class under the guidance of the instructor (Baker, 2000; Berrett, 2012; Foertsch, Moses, Strikwerda, & Litzkow, 2002). Moreover, flipping a class may, but doesn't necessarily, lead to flipped learning (Collins & Halverson, 2009; Flipped Learning Network, 2012; Garfield 1993, Keeler & Steinhorst 2001; Schaffhauser, 2009).

Davies, Dean & Ball (2013) stated that the process of changing from traditional learning model to a flipped learning model can be challenging due in part to a lack of facilities, internet accessibility and effective instructional leaders. Nevertheless, it is imperative to help students learn and develop their learning skills using innovative instructional methods (Musallam, 2010). Flipped learning is a pedagogical approach in which direct instruction transforms the group learning space into a dynamic, interactive learning environment where the teacher guides students as they apply concepts and engage creatively in the subject matter (FLN, 2014).

In the K-12 classroom, achievement test scores have traditionally been used to evaluate teaching and learning (Slavin, 2009). Ensuring students receive the best possible education is alleged to be the reason teachers are interested in how students perform academically and test scores serve as an alternate measure for this success (Hanushek, 2009). In order to accomplish the goal of academic success in the classroom, numerous instructional methods and strategies have been taunted as effective in the educational process (Moore, 2014). One such strategy is student engagement. Teachers have used student engagement instructional strategies in classrooms as they incorporate practices involving groups of students in active, academic collaboration with other students (Fewkes & McCabe, 2012). Student engagement is indicative of both the time and energy students invest in interactions with others through educationally significant activities (Kuh, 2001). The research indicates varying results related to flipped learning's ability to improve student outcomes (Clyde & Schiller, 2013; Driscoll, 2012; Rivero, 2013; Rosenberg, 2013; Roshan, 2011; Sohpia & FLN, 2014; Strayer, 2012). It is therefore important to have a vision of what educational practices should look like and what goals should be established related to student learning (Branford, Brown & Cockin, 2000; Michael, 2006; Strayer, 2012). This study adopts a phenomenographic approach to explore mathematics teacher's experiences with the flipped learning model in their mathematics classroom.

Statement of the Problem

Researchers posit that today's student has a digital footprint before they're even born and they learn differently than any other generation (Hake, 1998; Johnson & Renner, 2012). Lage, Platt and Treglia (2000) suggested that in order to meet the diverse needs of learners, instructors must utilize a wide variety of teaching styles. Teaching with various methods is not always possible due to time constraints. However, Lage, Platt and Treglia (2000) found that by using advancements in technology to create multimedia delivery, instructors were able to meet the needs of a diverse audience of learners. From the literature, a case has been made for the role of the flipped learning model (Bergman & Sams, 2012).

Describing student and teacher experiences, as well as the type of questions asked in a high school flipped mathematics classroom may provide formerly unknown insight into the full impact of this teaching method in K-12 education. Student perceptions of the flipped model have been studied at the high school and collegiate levels, and found to be encouraging (Huang & Normandia, 2009; Overmeyer, 2010; 2014; Toto & Nguyen, 2009). Consequently, all educators must examine how to successfully engage students' learning of mathematics by understanding how to hone their instructional practices (Classroom Window & Flipped Learning Network, 2012; Roscoria, 2011). This makes the role of the teacher more difficult (Fulton, 2012). As a result, not only do teachers struggle to gain student interest initially, they labor with getting them to be active learners. It is imperative that this be overcome in order to make advancements in education (Fischer, 2009), particularly in the mathematics classroom.

Significance of the Problem

Research suggests instructional practices are related to teacher quality and ability because highly qualified teachers have a strong mathematical and pedagogical knowledge (Asiedu-Addo & Yidana, 2004; Hill, Rowan & Ball, 2005; Hill, Schilling & Ball, 2004). Sadly, however, according to the U.S. Department of Education (2008), on average, 32% of the nation's mathematics and science teachers do not hold a degree in their teaching fields and this is drastically higher at the middle school level (Ball, Lubienski, & Mewborn, 2001). Nationally, 28 – 33% of public school secondary mathematics teachers lack state certification or licensure (USED, 2008).

In an urban school outside Detroit, almost half of the freshmen failed Algebra 1 in the fall of 2009. However, after implementing the flipped classroom instructional method in 2010, only 13% of the freshman class failed Algebra 1 (Roscoria, 2011). Crystal Kirch, a high school Algebra teacher, analyzed the data from her flipped and non-flipped Algebra classes. During the first semester of the 2011-12 academic year, she found students in the flipped Algebra class had an increase of 6.9% in the class average on tests, 14.2% increase of students designated proficient and a 10.3% decrease in students receiving an "F" as compared to the 2010-11 academic year (Kirch, 2012). The 2010-11 scores were as follows: 81% class test score average, 69.1% proficient and 17.3% failing (Kirch, 2012).

The reality that urban students are taught by teachers without a strong mathematical or pedagogical knowledge could be a contributing factor for poor student achievement and engagement in mathematics (Asiedu-Addo & Yidana, 2004; Love & Kruger, 2005; Schmidt, Tattoo, Bankov, Blomeke, Cedillo, Cogan, et. al, 2007;

Swafford, Jones & Thornton, 1997). According to Handel & Herrington (2003) teacher expectations were almost three times greater for suburban than urban students. Furthermore, teachers' expectations and instructional practices influence student achievement and engagement; as a result, understanding teacher views is an important measure in identifying ways to improve student mathematics achievement and engagement (Hoyles & Noss, 2003; Johnsom, 1992; Knight & Wood, 2005).

This study captured and described mathematics teacher experiences of the effectiveness, appropriateness and engagement behind using the flipped learning model in middle and high school mathematics classrooms in Northwestern Ohio and Southeast Michigan. Results of this study were shared with school faculty and administration to assist in determining both usefulness of and training for this method of instruction.

Research Questions

The following research questions guided this study:

1. What are middle and high school mathematics teacher's experiences with the flipped learning model?
2. How do middle and high school mathematics teachers describe their experiences in increasing student engagement using the flipped learning model?
3. What contexts have influenced middle and high school mathematics teachers' experiences with flipped learning?

Investigating these questions explains the role of mathematics teacher's understanding of flipped learning plays in how the formulate goals and techniques to learn about the phenomena. By asking middle and high school mathematics teachers to describe their processes for acquiring knowledge about flipped learning and the essence of what it means to teach using flipped learning are further documented.

According to Pramling (1996) people instinctively strive to understand their environment. Mathematics teacher's various interpretations of reality and their perceptions of the information they receive from it lead to a plethora of ways of learning about a phenomena. Teachers also develop rationales for validating observed truths and formulate principles to generalize their findings (Pramiling, 1996). The research questions posed study the unique experiences of mathematics teachers. The variations in these experiences are used to explain flipped learning in this study.

Purpose of the study

This study identified mathematics teachers' experiences with student engagement when using the flipped learning model versus traditional instructional methods in the mathematics classroom. It also examined how mathematics teachers in urban, rural and suburban middle and high schools in Northwest Ohio and Southeast Michigan currently address the needs of their students and the push toward the use of the flipped learning model in the mathematics classroom. It further explored the reasoning behind the use of the flipped learning model and teacher experience with its impact on student engagement in the mathematics classroom.

Methodology

A great deal of the research surrounding mathematics achievement of middle and high school students in urban, suburban and rural schools has focused on the digital divide or the achievement gap based on high stakes testing or international assessments (Belfield & Levin, 2007). Even fewer studies have looked at systemically altering school instructional models by bridging the digital divide to tackle the achievement gap. The number of studies linking middle and high school mathematics student engagement to academic achievement in urban, suburban and rural schools is relatively small although this premise is widely accepted among the field. There have also been few studies to support the flipped learning model to influence student engagement in the middle and high school mathematics classroom in urban, suburban and rural schools. Therefore the researcher sought to determine the relationship between such factors and their impact on students in urban, suburban and rural mathematics classrooms as experienced by teachers.

By establishing a research design that allowed the researcher to capture the experiences of mathematics teacher's use of flipped learning, the foundational questions of phenomenography were examined. This perspective is valuable for creating a model showing the variation in ways mathematics teachers understand student engagement when using the flipped learning model versus traditional instructional methods in the mathematics classroom and how these understandings relate to each other. The qualitative research methodology used to answer the research questions for this study was phenomenography. Phenomenography is an educational research method that is exploratory and descriptive because it maps the qualitatively difference ways the participants experience, conceptualize, perceive and understand various aspects of a phenomenon in the world around them (Bowden, 2000; Greeno, 1997; Marton, 1986; Marton & Booth, 1997).

Phenomenography is a beneficial design to investigate the beliefs of individual mathematics teachers about their experiences of using the flipped learning model. Trigwell (2000) perceives the strength of phenomenographic research as being "consistent with my everyday work. Trying to understand the way academic staff think about teaching or learning or about how students think in aspects of chemistry is an important part of my job." (p. 58). The data collected in phenomenographic study can be used to provide viable information to help educators to think about teaching and learning.

Phenomenography is related to a field of knowledge, which is defined by having experience as the subject of the study. It takes on a non-dualist phenomenological perspective. As a result, the object and subject are not separate and independent of each other. When flipped learning and the mathematics teacher using flipped learning are considered, one cannot assume flipped learning and the mathematics teachers' conceptions are separate (Walker, 2003). The objective is, however, not to find the singular essence, but the variation and the architecture of this variation by different aspects that define the phenomena (Booth, 1997; Marton, 1986; Walker, 2003). The framework for a qualitative study is "a situated activity that locates the observer in the world that consists of a set of interpretive, material practices that make the world visible. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 2011, p.3).

According to Marton & Booth (1997, p. 177), "teachers teach according to their manner of understanding the subject as a whole." Combining qualitative differences among the students with the qualitative variations among teachers makes it obvious how radically different the content of learning can be for students. Trigwell & Prosser (1997) conducted a study that revealed teacher generally focus on content than on the learner. If teachers are made aware of the qualitative different ways students experience the content, the instruction could be redirected to focus these levels of awareness. Even the differences among mathematics teachers can be directed to a common, well-documented outcome space using this method (Marton & Booth, 1997).

In a phenomenographic study, the researcher positions herself towards the participants' ideas or experiences of the world, in this case the classroom and defers her own perceptions of reality (Marton, 1986). By deferring my own assumptions, the researcher acquired the phenomenon from the participants' perspective. The participant is the academic and the researcher takes the role of the student, experiencing the phenomenon and asking questions to learn more intensely about the phenomenon through the participant (Bowden, 2000). This is a common focus in qualitative research.

To ensure validity and authenticity a process of triangulation will be applied and several data collection tools will be employed in this project. The main source of information will be gathered from semi-structured interviews. Perceptions about engagement cannot be directly observed and Patton (2002) suggests using interviews to understand the interviewee's "inner perspective." The interviews will provide a basis for understanding individual "emic constructions" (Creswell, 2009). Observations and a research journal will supply the remaining data.

The data was analyzed during and after their collection. The interviews were transcribed, coded and triangulated with the observations and research journal. During the analysis stage, themes emerged resulting in precedents being established. Data reduction occurred throughout the length of the study. The process of data reduction included delving deeper into the analysis of the transcripts through coding and themes. According to Huberman & Miles (1994), the next step was to organize the themes into a data display. This process afforded the researcher an opportunity to continue the coding process, allowing for conclusions to be made and substantiated.

Definition of terms

Constructivism - a philosophy of learning based on the science of how people acquire knowledge by being able to relate new information to existing knowledge and create patters (Clements & Battista, 1990). More specifically, constructivism is the theory of learning that espouses how students should construct their knowledge through engaged learning activities.

Engagement - a multifaceted construct that includes involvement in academic performance, classroom behavior, interpersonal relationships, and school community (Jimerson, Campos, & Grief, 2003).

Flipped learning – an instructional practice that leverages technology to make direct instruction available in an individual learning space instead of in a group setting (FLN, 2014), it reverses the traditional instructional approach. Flipped learning moves the lecture outside of class via technology and moves homework inside the classroom via learning activities.

Student engagement – the involvement of students in their own learning

Student Achievement - academic achievement as measured by test scores

Traditional instruction – instruction based on a unified curriculum where emphasis is placed on direct instruction, lectures, seatwork and little or no social development. Students are supposed to learn the facts and concepts by rote and practice of the attendant skills until they can demonstrate their mastery of certain tests (Klein, 2003).

Limitations of the Study

Teachers have a variety of ideas, perceptions, experiences, and background knowledge when referring to student engagement. This prior knowledge may affect the way teachers view and respond to the questions in the interview. Teachers may fail to respond to the questions candidly for fear that their school system might be portrayed in a negative manner. Efforts were made to ensure that individual responses were kept confidential. However, the interviews took place during a time of year when the teachers have prior professional duties that make the interviews an additional burden to them. This study will be limited to six middle and high school mathematics teachers and the data may not be generalizable to other populations. Also common in qualitative research is the concept of sample size. As stated by Marton & Booth (1997), "a phenomenographic study always derives its description from a smallish number of people chosen from a particular population" (p. 113). Although the participants in the study were limited in expressing experiences and awareness, a sample size of six did result in satiety information.

Chapter Two

Literature Review

This study takes a constructivist view and a phenomenographic approach. This chapter reviews the literature related to teaching mathematics. The perspective taken in this study is that teaching and learning are related and occur within a system of varied interactions between the teacher and the student. This chapter, also, describes the theoretical frameworks drawn upon through inquiry and phenomenography. Activity theory is used to supplement phenomenography by analyzing an aspect of the system, specifically, the learning context. The remainder of the chapter will discuss in depth phenomenography, the limitations of phenomenography and briefly describe activity theory.

Constructivist view

The constructivist view of learning perceives knowledge as something that is inside the student. Deep learning occurs when a student can link new knowledge to existing knowledge, so the "new concept forms part of the cognitive structure of the learner" (Yip, 2004, p. 77). In the constructivist classroom, students are viewed as thinkers with emerging theories about the world (Brandt, 1997). Roehl, Reddy & Shannon (2013) identified three distinct roles of students in constructivism: "the active learner, the social learner, and the creative learner" (p. 45). Constructivist theory in the high school environment can be interpreted in numerous ways, but students in control of their learning is at the heart of the model (Pajares, 1992). This echoes the ideas of conceptual change, which describes a concept as a human intervention that is a way of describing relationships between events and other concepts. According to Cakir (2008) “concepts are formed and language is the guide” (p. 8).

Language is central since it is the mode of communication between the teacher and student, where things are put into words and new concepts explained and formed in the student’s mind. Piaget (1978) stated the ideas of assimilation and accommodation are relevant to how meaningful learning occurs. Assimilation happens when a student encounters a new concept that fits into their prior knowledge. However, all new information will not be able to be assimilated by students. For example, the student may not understand the new concept or find it relevant or meaningful (Limon, 2001). In this instance, the teacher must find ways to encourage the student to change their thinking in order to accommodate the new concept. It is important for students to feel inquisitive and be motivated to build upon their prior knowledge; thereby, inspiring them to learn the new concept.

Constructivist teaching approaches are vital in developing students’ conceptual understanding and proficiency to communicate acquired ideas in mathematics because it strives to be student-centered (Pratt, 1992). These approaches include teacher reinforcement of independent thinking by student’s creation of inquiry-centered lessons and facilitation of shared meanings. The theory of constructivism is the basis for mathematics teaching approaches (McKenzie, 2003). In a study analyzing the effects of problem-based lessons on developmental math students’ problem-solving skills, Kinney & Robertson (2003) reported higher engagement and a statistically significant increase in performance on a post-test examination. Tice (1997) affirms that, “application and active experimentation are essential to true acquisition knowledge” (p. 19).

Slavin (2009) defined constructivism as, "the view of cognitive development that emphasizes the active role of learners building their own understanding of reality" (p. 32). In this view, students are not similar to sponges through absorption of new information. In other words, students must actively participate in classrooms, which support constant reflection of one's own ideas, as well as the correlation to others' ideas (McLaughlin, 2012). One component of constructivism, the use of physical actions, can prohibit students from simply memorizing information and promote the use of senses to obtain core meaning (Vygotsky, 1978). This action encourages students to gain control of their own learning. As stated by von Glaserfeld (1996), "for whatever things we know, we know only insofar as we have constructed them as relatively viable permanent entities in our conceptual world" (p. 19). Designing classroom activities, promoting communication and justification of ideas is important in aiding students develop problem-solving skills (Piaget, 1978). There is boundless value in the interpretation of correct mathematical language, justification of ideas and sharing ideas with others (Ball & Bass, 2000; Schoonmaker, 2002).

Mathematics education strongly relies on constructivism and its exploratory and inquisitive strategies. Students can construct meaning in mathematics from one another or from use of individual objects, both of which are part of experiences (Leinhardt & Greeno, 1986; von Glasersfeld, 1997; Vygotsky, 1978). At all levels, students can benefit from hands-on approaches. Typically, students who perform lower in mathematics predict ideas in an entirely different light when using concrete learning experiences. Therefore, all students can learn mathematics given applicable instruction that is tailored to meet their needs. This type of instruction nurtures the relationship between procedural and conceptual knowledge in a deep and rational approach. The use of hands-on, activities in learning was explained by Piaget (1978) as follows, "Once these mechanisms are accomplished, it becomes possible to introduce numerical data which take on a totally new significance from what they would have had if presented at the beginning" (p. 101). Actually, minus such approaches, students oftentimes approach mathematics in a disorganized manner through the use of already known procedures, which are destructive to the use of reasoning skills (Piaget, 1978; Vygotsky, 1978).

Instructional Strategies

Constructivism is considered the source for the theories of both problem-based and active learning (Krauss & Boss, 2013). According to Krauss & Boss (2013) problem-based learning originated in the late 1960's at the medical school at McMaster University in Canada due to dissatisfaction with teaching practices at that time. Several elements that are essential to effective problem-based learning have been identified (Barron & Darling-Hammond, 2008; Ertmer & Simons, 2005; Hung, 2008) as follows:

1. A realistic problem or project:
    a. Aligns with students' skills and interest
    b. Requires learning clearly defined content and skills
2. Structured group work
    a. Groups of three to four students, with diverse skills levels and interdependent roles
    b. Team rewards
    c. Individual accountability, based on student growth
3. Tiered assessment

a. Multiple opportunities for students to receive feedback and revise their work

b. Multiple learning outcomes

c. Presentations that encourage participation and signal social value

4. Participation in a professional learning community

a. Collaboration and reflecting upon problem-based learning experiences in the classroom with colleagues

b. Courses in inquiry-based teaching stategies

Leandro (2005) and Newman (2003) both present meta-analytic results on the effectiveness of problem-based learning. Combined results indicate an overall positive effect for problem-based learning compared to traditional instruction.

Active Learning

Active learning and encouragement of comparison of new ideas to prior knowledge is aligned with constructivism (Brown, Collins & Dugid, 1998; Piaget, 1978; von Glaserfeld, 1997; Vygotsky, 1978). Active learning exercises, like teamwork, debates, self-reflection, and case studies, that prompt students' engagement and reflection encourage them to explore attitudes and values, while fostering their motivation to acquire knowledge and enhance skills (Prince, 2004). Evidence shows that engaging students in active learning enhances their learning outcomes and improves their motivation and attitudes. Moreover, active learning stimulates higher-order thinking, problem solving, and critical analysis while providing feedback to both the student and instructor (Branford, Brown, & Cocking, 2000; Prince, 2004). Numerous results of empirical research and discussions about mathematics teaching over the last three decades support the view that an active approach to the teaching and learning of mathematics may prevent adverse and negative effects (Ball, 1993; Christakis, Zimmerman, DiGiuseppe, McCarty, 2004; Freeman, et. al, 2014; Hake, 1998; Springer, Stanne, & Donovan, 1999).

Clearly, an alternative approach to teaching and learning involves changes in the pedagogical practices of mathematics classroom. A growing body of literature consistently points to the need to rethink classroom instruction (Ball, 1993; Batitista, 1994; Freeman, et. al, 2014; Grouws & Cebulla, 2000; Prince, 2004). Grouws & Cebulla (2000) states that mathematics instruction should be focused on meaningful development of important mathematical concepts. Research shows that students' attention declines significantly and progressively after the first ten minutes of class and the average attention span of students is fifteen to twenty minutes at the beginning of class (Hartley & Cameron, 1967; MacManaway, 1970). As a result, their view reflects the learner as an active participant in the pedagogical processes in the classroom (Battista, 1994; Grouws & Cebulla, 2000). Hung, Tan & Koh (2006) defines active learning as "students taking responsibility for their own learning during which they are actively developing thinking and learning strategies and constantly forming new ideas and refining them through their conversational exchanges with others" (p. 30). Therefore, active learning acts as a subset for both peer-assisted and problem-based learning (Prince, 2004).

The relationship between peer-assisted learning and problem-based was clarified by Prince (2004) as "problem-based learning is always active and usually collaborative and cooperative" (p.1). Active learning model is characterized by student's being more involved in problem-based learning, multiple small group activities, Bloom's taxonomy, and exploration (Mayer, 2009). The Figure 1 identifies the process by which students learn based upon active learning and traditional learning.

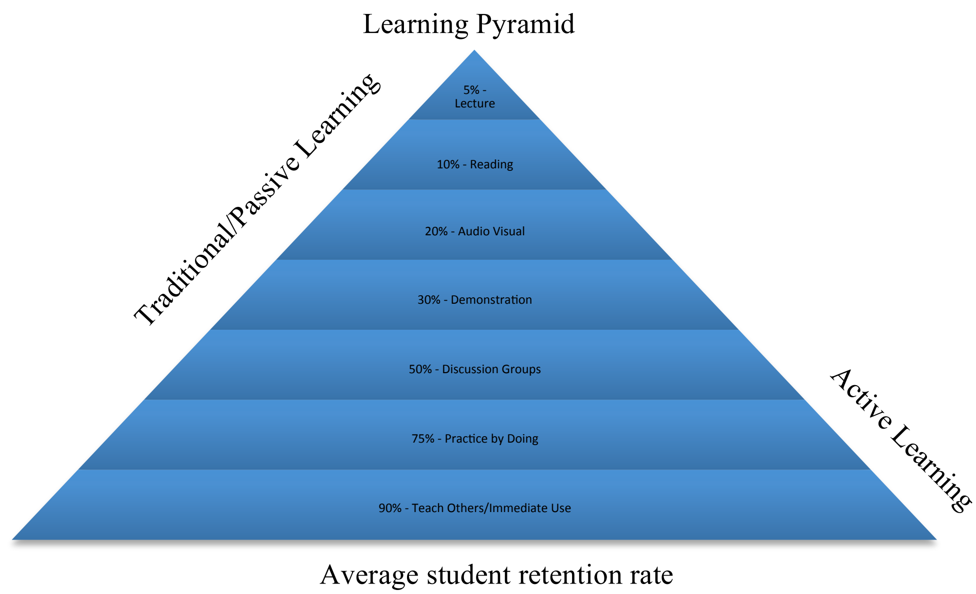


Figure 1. Lalley, J.P. & Miller, R.H. (2007). "The learning pyramid: Does it point teachers in the right direction? *Education,* 128(1), 64-79.

Flipped learning

Flipped learning is not a new concept, but one that has evolved over time (Baker, 2011). The concept is an outgrowth of reversed or inverted teaching. Before flipped classrooms, educators used instructional videos along with televisions and radios to deliver content and instruction (Strayer, 2007). Khan, although not the first open source entity, has been successful at delivering educational content through video (Khan Academy, 2014). Because of increased access to technology and through the work of many educators experimenting with the concept of flipped learning, there has been a rise in its use at the secondary level (Gorman, 2012). Secondary classrooms have documented flipped learning in an attempt to increase achievement and engagement as compared to a traditionally instructed class (Bergmann & Sams, 2012; Roscoria, 2011;

Lage et. al., 2000). Essentially, flipped classrooms removed traditional educational lectures from face-to-face instructional time to providing an online format that better promotes learning (Bowers & Zazkis, 2012).

Lage, Platt & Treglia (2000) designed and applied a concept referred to as "The Inverted Classroom" and expected students would view lectures prior to class and spend class time working on difficult concepts and in small groups. They provided students with numerous tools to gain initial exposure to material outside of class, including but not limited to, textbook readings, lecture videos, and slide presentations (Bishop & Verleger, 2013; Mazur, 1991).

Evident in the research, technology has reached a level where the time has come for real educational reform that increases student achievement and engagement while teaching pertinent 21st century skills (Bishop & Verleger, 2013). At the heart of this concept is the idea of flipping traditional instructional practice with what students traditionally are assigned outside the classroom (Bergmann & Sams, 2009, 2012; Bishop & Verleger, 2013). Basically, lecture is assigned for homework, affording more time in class for application of new knowledge, active learning, and engagement (Bishop & Verleger, 2013). Flipped learning changes this typical homework scenario:

> A 13-year old sits at the dinner room table with a paper filled with numbers, letters, and shapes. She sort of remembers what her teacher said about the Pythagorean theorem, but not really. Her mother can't help. She's alone and stuck (Talbert, 2014a).

The concept of flipped learning provides this student the chance to learn the Pythagorean theorem at home prior to coming to class by watching a video provided by her teacher. She can watch the video, re-wind, stop, or pause it based upon her needs. In class the next day, she can practice working the theorem in conjunction with other students and the teacher. According to Bermann & Sams (2012) she would have the expert right there to assist her to answer the questions she was unable to answer at home.

Bergmann & Sams (2012) introduced flipped learning to their students who had missed class and this method has caused a paradigm shift in education. They claim that by using flipped learning, the teacher no longer acts as lecturer while students take notes, but instead students are active learners (Hamdan, McKnight, McKnight, & Afstrom, 2013). This learning model incorporates any use of Internet technology to influence the learning in a classroom, in order to afford the teacher more time interacting with students instead of lecturing (Bergmann & Sams, 2012).

Moreover, teachers and students around the world began contacting them once they posted their videos publicly online. It wasn't too long before they began conducting professional development workshops on what they were calling the "pre-vodcasting" method. Their workshops were meet with enthusiasm and gratitude because the concept was simple and could potentially reform education (Bergmann & Sams, 2012).

After searching the Internet, they were unable to find anyone else using this method. For a short time, the name was changed to reverse instruction, but, once Dan Pink wrote about the method and called it the flipped classroom, the term stuck (Bergmann & Sams, 2012). In 2011, during his TED talk, Sal Khan used the term "flipping the classroom" and since then interest in the flipped model has grown tremendously with new articles, research, and blogs (Khan, 2014). Today, Bergmann &

Sams conduct seminars and workshops all over the country (Bergmann & Sams, 2012; Noonoo, 2012).

Flipped learning affords the instructor the opportunity to engage the varied learning styles in the classroom and implement pedagogies that encourage problem-based learning and inquiry oriented strategies during class time (Ash, 2012; Bergmann & Sams, 2012; Lage & Platt, 2000). Additionally, flipped learning empowers the instructor to develop various learning experiences that are appropriate for the individual student (Bergmann & Sams, 2012).

The research on flipped learning is relatively new (Ash, 2012; Bergmann & Sams, 2012; Driscoll, 2012; Gorman, 2012; McKnight, et. al., 2014; Overmyer, 2014). However, engaging students in active learning and appropriately assessing their performance are essential for enhancing students' learning experiences when using flipped learning (Noonoo, 2012). Flipped learning encourages students to explore the material and develop new skills on their own, with the understanding that they will apply this new knowledge through various active learning exercises during class time. Improved outcomes using flipped learning can be explained, in part, by active learning theory (Slavich & Zimbardo, 2012).

Pedagogical framework for flipped learning

This research studies teacher experiences with the effect of the flipped learning model on mathematics instruction and student achievement. Since learning of mathematics is built upon student's prior knowledge, it is essential that students understand the foundations prior to progressing in mathematics (Overmyer, 2014). In mathematics, failure to learn prerequisite skills is apt to affect students' learning of future skills (Brewer, 2009). Too often in math classes, students keep quiet when they don't understand a piece of information. Understandably, students can be intimidated by raising their hands and exposing their confusion in front of a large group, however, other students quite frequently have the same questions.

In order to meet the demands of educational reform and 21st century teaching and learning, the themes of the classroom must change. In other words, flipped learning requires change (a) from a learning environment focused on the teacher to student focus; (b) to blended learning where technology is used daily; and (c) in pedagogical practices that have a focus on differentiated, mastery and active learning to increase students' engagement in their learning.

Flipped learning promotes an active classroom supported by social constructivist learning theories (Clements & Battista, 1990; Cobb, 1988; Petress, 2008). This theory has two major goals for mathematics instruction. First, students should develop mathematical structures that are more complex, abstract and powerful than the ones they currently possess so that they are increasingly capable of solving a wide variety of meaningful problems. Second, students should become autonomous and self-motivated in their mathematical activity. As a result, students believe that mathematics is a way of thinking about problems. "They believe that they do not get mathematical knowledge from their teacher so much as from their own explorations, thinking and participation in discussion" (Cobb, 1988, p. 93).

The flipped classroom affords the dissemination of information outside of class in order for the active, social and creative learner to experience cognitive conflict in a controlled, cooperative setting (Beesley & Apthrop, 2010; Hamdan, et. al., 2013;

Wenger, 1999). The flipped learning teaching approach offers educators a solution to address the problem of how to teach the 21st century learner. This model, if applied effectively by middle and high school instructors, specifically mathematics instructors, through interaction with mathematical tasks and other students, cause the student's own intuitive mathematical thinking to gradually become more abstract and powerful (Baker, 2011; Prince, 2004).

Blended Learning

Blended learning allows the teacher to promote high quality, personalized instruction through a combination of face-to-face instruction and instructional technology (Davies, Dean, & Ball, 2013; Greenberg, Medlock, & Stephens, 2011). In a blended learning classroom, the teacher is able to provide some content delivery to students that meets their specific needs. The students are able to access this instruction via the use of various types of technology in or out of school. Effective teachers have always differentiated instruction and incorporated multimodal learning in their classrooms (Bryson & Hand, 2007; Bull, Ferster, & Kjellstrom, 2012). Previously, this type of teaching required intensive preparation and manual data crunching (Bishop & Verleger, 2013). The use of blended learning allows teachers the extra time needed to engage their students in classroom discussion, labs or project based assignments (Beesley & Apthorp, 2008; Hamdan, et. al., 2013). As a result, the teacher can act as a facilitator helping students with misunderstandings and the application of concepts (Riordan & Noyce, 2008).

Today's student expects schools to be as technology rich as the world around them (Davies, Dean, & Ball, 2013). They play video games and crave the same type of engagement in the mathematics classroom. Teachers and school administrators need to push into the future. The future of learning calls for customization and personalization. A survey conducted by Project Tomorrow (2011) showed parents expect their child's education to be more interactive, have more communication and information about grades, attendance, and different aspects of their child's academic lives. Consequently, blended learning and the data it provides fulfill these desires (Greenberg, Medlock, & Stephens, 2011). In a survey of students, conducted by Project Tomorrow (2011), it was found that students wanted flexibility and personalization. As advances in technology progress, students will have the ability to learn anytime, anywhere. Blended learning is synchronous with a live classroom where students can join together in person to interact with the teacher or each other. It is also synchronous in an online environment, where the teacher broadcasts a lesson online and they both chat and interact live. Additionally, there's an asynchronous component where students are self-paced and can go online and learn at their leisure. Students don't have to be online at the same time.

Blended learning strategies are used effectively by thousands of teachers, however, the real power of technology is leveraged by teachers to shift the focus from time-to-learn, to create competency-based environments where students progress when they show what they know (FLN, 2012; Herreid & Schiller, 2013). Moreover, it has the potential to revolutionize the mathematics classroom in a way that offers a fundamental redesign of mathematics instruction through the following:

- Impacting technology, blended learning can allow students to learn at their own pace, use preferred learning pathways and receive frequent and timely feedback on their performance for a greater learning experience.

- Teachers can leverage technology to increase student-teacher interaction, increase parental involvement and spend more time helping personalize learning for students. Additionally, teachers will have more time to focus on more rigorous learning activities as they spend less time on mediocre tasks.

Specifically, blended learning provides for the creation of a strong, supportive educational environment that promotes rigor and high expectations for all students, as well as providing for more personalized learning (Pink, 2010; Rosenberg, 2013).

Student Centered Environment

Shifting to student-centered learning environments requires an understanding of student-centered pedagogies that include individualized learning, mastery learning, active learning, cooperative learning, and differentiated learning (Bloom, 1968; Boaler, 2000; Guskey, 1990; Marzano, 2007; Michael, 2006; Prince, 2004; Tomlinson, 1999). Many of the acclaimed successes of flipped learning include students working at an individual pace toward mastery of content and students working with the teacher and their peers to assimilate what they are learning (Bergmann & Sams, 2012; Goodwin & Miller, 2013).

Far too many students, today view mathematics as a subject that must be survived instead of a foundation of inventiveness or a manner of thinking that can improve their understanding of the world around them (Attard, 2009). For example, one third of U.S. eighth graders scored proficient or higher on the 2013 National Assessment of Education

Progress (National Center for Education Statistics, 2013) and only 45% of 12^{th} grade students in the class of 2011 who took the ACT test demonstrated readiness for college-level mathematics (Clyde & Schiller, 2013). However, teachers have the ability to transform the mathematics classroom into an engaging environment where students take control of their learning and make meaningful connections to the world around them.

In the United States, mathematics lessons have traditionally consisted of a teacher lecturing followed by student practice with emphasis placed on the application of procedures (Hiebert, et. al., 2003). This type of rote instruction was deemed effective and a driving force during the mathematics reform initiatives of the 1980s (Stigler & Hiebert, 2004). Research has shown that when properly applied, rote memorization is a consistently effective teaching method. For example, a meta-analysis of 85 academic intervention studies with students with learning disabilities found that regardless of the theoretical orientation of the study, the largest effect sizes were obtained by interventions that included systematic drill, repetition, practice, and review (Heward, 2003). Consequently, instruction, today must complement the plethora of learning styles teachers are faced with on a daily basis. Therefore, student-centered instruction draws from multiple theoretical perspectives (Boaler, 2000; Hiebert et. al., 2003; Fischer, 2009; Trilling & Fadel, 2009; Vygotsky, 1978; Zull, 2011). This type of instruction places student's at the epicenter of the learning process, thereby preparing them to be successful both inside and outside of the classroom.

Features of student-centered instruction
• An emphasis placed on 21^{st} century knowledge and skills (problem-solving, critical thinking and communication)

- Students actively engaged in instructional activities that builds on their prior knowledge and connecting to personal experiences, through group work
- Learning environment characterized by trust and strong relationships between and among the teacher and students
- Focus on individual student through differentiation, scaffolding and opportunity of choice

Digital natives respond to structures and routines in the classroom and this makes flipped learning appealing to them (Prensky, 2008). The flipped classroom is student centered and engaging theoretically since students can pace their learning by reviewing content outside of the traditional classroom and teachers can maximize face-to-face interactions by checking for and ensuring student understanding and synthesis of learning (Hamdan, et. al, 2013; Green, 2012; Johnson & Renner, 2012). In addition, lessons are made available anytime and anywhere. The concept of time shifting and the proliferation of smartphones made webinars an important form of media delivery. The lesson that one student views on his tablet while on the bus can be watched by another student in their living room. A third student can take in the material with a friend and another student may need to watch it at the library multiple times. The flipped class makes all of these scenarios viable.

Prensky (2008) uses the term "digital natives" to describe students born in the modern world. He compares them with native speakers of a language, while the rest of us are immigrants who will probably never completely understand the nuances and tendencies of the culture. In addition, he cites evidence from Baylor College of

Medicine that, “it is very likely that students’ brains have physically changed and are different from ours” (p. 1). Digital natives are extremely comfortable with technology, as that’s all they have known. As a result, they exhibit a preference for using technology for learning (Nicolette & Merriman, 2007).

McKinney, Dyck & Luber (2009) suggest that lectures provided via webinars, podcasts, or videos were both appealing to students and had a positive effect on learning. They designed a quasi-experimental design comparing audio lectures on an iPod with identical face-to-face lectures. The results indicated that the audio lectures were effective and the student surveys indicated that the group with the iPods listened to the lectures multiple times.

The flipped classroom and flipped learning model are receiving increased attention from educators and researchers due in part to its benefits to teaching and learning, meeting the needs of digital natives, and the availability of emerging technologies (Prensky, 2008). Flipped learning models and flipped classrooms have an exponential amount of potential and it’s imperative to study how teacher experiences and perceptions can effectively impact student learning and engagement.

Mathematics teacher experiences

Since its introduction, the flipped learning model has been used across a number of high schools with significant decreases in student failure rates, and students who formerly performed at a lower level were now more enthusiastic about participating in classroom activities (Butt, 2014). Mathematics teachers agree that since flipping their classes, it has enabled them to find the class time to create a collaborative, student-centered learning environment. In the flipped mathematics classroom, the role of the teacher changes to that of facilitator who assists students to take responsibility for their own learning (Baker, 2011; Sullivan, McDnough & Harrison, 2004). Students have become more actively engaged, and the teacher has much more individual contact with students. In fact, teachers report there exists a true student-centered mindset (Attard, 2009; Kirch, 2012; Martin, 2006).

The flipped mathematics classroom has also increased teacher access to students' thinking and reasoning, helping them better understand their students and what they were learning. The flipped model allows more time to interact with students, watch the ways in which they engaged with problem-solving practices, and get a clearer picture of how time spent working on rich tasks in class influenced their knowledge and practices as mathematics learners. This specific outcome strengthened their practice as teachers and made them feel that their investment in setting up the flipped classroom was worthwhile (Mumper, 2013).

As with any change in teaching practice, the flipped learning model has meant shifts in how we plan for classes and how we select mathematical tasks (Knight & Wood, 2005; Roehl, Reddy & Shannon, 2013). The mathematics teacher carefully selects and utilizes flexible features of the mathematics curriculum in order to design instruction that meets the needs of diverse learners (Bull, Ferster, & Kjellstrom, 2013). Specifically, the mathematics teacher identifies low level and high-level cognitive skills and decides what and how to deliver it in a manner that maximizes class time and leads to greater student engagement (Mumper, 2013). The flipped classroom adds a significant technological component into the mix as well. Getting started on leveraging the benefits of this model means making smart choices so as not to saturate one's planning time with handling the technology rather than thinking about the mathematics content we want our students to learn. The flipped learning model has improved students' mathematical knowledge and provided time to engage in high cognitive demand tasks that embody the recommendations of the Common Core Standards for Mathematical Practice (CCSSI 2010; Knight & Wood, 2005).

Many mathematics teachers using the flipped learning methodology in their classrooms have identified that there is no single standardized method of "flipping a classroom." However, research suggests that "any learner-centered educator would provide activities in the classroom that are action-based, authentic, connected, and collaborative, innovative, high-level, engaging, experience-based, project-based, inquiry-based, and self-actualizing" (Hamdan, et. al., 2013, p. 17). Furthermore, Rivero (2013) included peer instruction, active learning and pre- and post-class modeling to reduce cognitive load, as important aspects of flipped learning.

Research indicates that compared to those in traditional lecture-based classes, students in active learning environments show improved retention and better conceptual understanding of learned material (Sezer, 2010). These results are attributed to the contrasting roles of passive and active learners in the educational process. While passive learners exist solely as receivers, active learners are full participants in the process, allowing them to add to their retentive capabilities through continued self-reinforcement (Bhatia, 2014; Petress, 2008). Several mathematics teachers and the Flipped Learning Network (2014) agree that students are active learners, which creates a dynamic and rich mathematics classroom that connects both teacher and student (Aronsom & Arfstrom, 2013; Driscoll, 2005; FLN, 2012; Mumper, 2013; Talbert, 2014a).

For example, one study looks at a flipped model in AP Calculus (Strauss, 2012). The instructor created about four videos per week with a length of 20 to 30 minutes each. This method is unique, in that the videos were not all created in advance, but were often created only a few days in advance. This allowed the instructor to customize the videos based on the progress of the course (Roshan, 2011). The following shows the AP Calculus exam results (Roshan, 2011):

AP Calculus Exam Results

				AP Score			
Year	n	5	4	3	2	1	Average Score
2009-10 (T)	10	23.53%	35.29%	23.53%	11.76%	5.88%	3.59
2010-11 (F)	17	33.33%	44.44%	22.22%	0%	0%	4.11

The AP Calculus exam is scored on a scale of 1 to 5. A score of 3 is sometimes good for college credit (Grove, 2011). Important to note is that the sample size was small and the teacher had an extra year of overall teaching with the flipped method. Nevertheless, it is encouraging that all students scored at least a 3 on the exam when the flipped method was used.

In surveys administered by Byron High School mathematics teachers, 87 percent of parents and 95 of students preferred flipped learning to the traditional lecture format for mathematics (FLN, 2014). Many students commented that they prefer interacting with their peers and teachers during class time, the availability of assistance in-class, and possessing the ability to re-watch the lectures if needed. The survey also suggested that because of an increase in one-on-one time with students in class, teachers and students are able to build relationships (Mumper, 2013).

Kirch (2012) conducted a similar study in an honors pre-calculus class for high school juniors and seniors. During the 2010-11 school year the classes were not flipped and all lessons were taught traditionally with homework being done outside of class. However, during the 2011-12 school year, the teacher conducted a trial flipped classroom during the fall semester and went full flipped in the spring. The flipped classroom included all lesson instruction conducted via video produced by the teacher and most practiced on in class. Students were mandated to watch the lesson, write a summary, and ask a Bloom's Taxonomy type question at home. In class, students reviewed the lesson, answered their questions and worked on practice. Activities and methods were structured, but "varied based on content and throughout the week to mix things up" (Kirch, 2012, p. 4). Results of the study showed a 5% increase in class averages from the pre-flip year to the flipped class using identical measures. Similarly, results showed a 12% increase in students receiving final grades of A or B, with nearly a 10% decrease in students failing the course. There were no reported means, sample sizes or standard deviations, making statistical significance and effect sizes unobtainable.

A quantitative experimental research study on the effects of flipped learning on students' achievement compared a section of linear Algebra taught in the traditional lecture format with a section of linear Algebra taught in a flipped model (Love, Hodge, Grandgenett, & Swift, 2013; Strayer, 2012). The same instructor taught both sections.

Of the 55 students who agreed to participate in the study, 27 were in the flipped section and 28 were in the traditional section. Students were not given a choice regarding the method of instruction. The instructor randomly chose one student for the flip and the other to be traditional. The students selected the time slot that fit their schedules and were unaware of the method of instruction until the first day of class. Students in both sections completed the same work.

Students in the flipped section were required to complete pre-class readiness assessments daily via the course learning management system, which were designed to assess learning and to provide students an opportunity to ask for more explanation about certain topics in class. Each assessment consisted of three questions. The first two questions related specifically to the content, but were designed to promote mathematical discourse and were not simply repetition of definitions. The third question was open ended and asked what the student found difficult, confusing or interesting in the video lesson. The answers on the third question were used to guide the instructor in what to discuss and cover in upcoming classes.

The traditional section was the control group and the flipped section was the experimental group. The dependent variables were student scores on the three common midterm exams and a comprehensive final exam. Each of the two sections met for two 75-minue classes weekly. The traditional section was taught with roughly the first half of each class period used for questions and the instructor working some of the homework problems on the board. In the second half of the class, the instructor lectured on new material and worked through some examples. In the flipped section, the first 15 minutes were spent in instructor led discussions with students. The instructor discussed the daily assessment questions and addressed student questions. During the remainder of the class, students usually worked on problems from the textbook.

Data were not provided for the midterm exams, even though students were tested three times. The only analysis was that the performance on the second exam relative to the first exam, the average change in scores for the students in the flipped section was significantly higher than for those in the traditional section ($p<0.034$). When comparing the third exam to the first exam, the average change in scores for those in the flipped section was again considerably higher than for those in the traditional section ($p<0.012$). The analysis was done using non-parametric Mann-Whitney *U* test because the data was not normally distributed, precluding the use of a traditional sample *t*-test. A simple descriptive comparison showed that average raw scores in the flipped section was 89.5 compared to 87.4 in the traditional section (Love, Hodge, Grandgenett, & Swift, 2013). The study did not state a standard deviation so an effect size was unobtainable from the given data.

A survey was given at the end of the semester. Results showed that 74% of students in the flipped section had a positive attitude about the flipped classroom approach. The survey showed that 78% agreed that the group work helped them to become socially more comfortable with their classmates and over 70% agreed that explaining a problem to their partners helped them to develop deeper understanding of the material.

A significant result was that students in both sections were asked if they were more comfortable talking with classmates in this class or other mathematics classes they had previously taken. Nearly 56% of students in the flipped section agreed with this statement, while 21% of the students in the traditional section agreed with the statement. The summary stated that even though the results on the common final exam were similar, the surveys showed that the students in the flipped section enjoyed the class more and that retaining interest is an important fact for STEM majors (Frederickson, Reed & Clifford, 2005; Love, Hodge, Grandgenett, & Swift, 2013; Strayer, 2012).

Traditional instruction versus flipped learning

Traditional instruction is indicative of the popular view of school in the United States. Students receive instruction from the teacher who provides information to the students. Class periods are lecture based and students are expected to be cognitively active while being physically inactive. In this instructional style, students are expected to answer questions generated by the teacher causing students to be considered passive learners (Steinhorst & Keeler, 1995). This type of instruction doesn't engage students actively and most students of any age cannot maintain such passive behavior for an extended period of time (Akingoglu & Tandogan, 2006; Cangelosi, 2003). On the other hand, in a flipped classroom students often watch lecture videos outside of the classroom, actively take notes, write questions, and re-watch sections of the content that they want to obtain greater clarity. Afterwards, they complete assignments and activities in the classroom, facilitated and supervised by their teachers who model what to do and provide expert feedback. Flipped classrooms build on the concept of active learning.

Traditional instruction is teacher centered and focuses on the manner in which the instructor instructs. The traditional instructional model explores various methods of transmitting knowledge from the teacher to the student. Researchers who have studied the role of traditional instruction exhibit consistency in their definitions (Hake, 1998;

Roehl, Reddy & Shannon, 2013). Hake (1998) conducted a comparison study where he introduced the idea of the "passive learner" (p. 64). Ironically, almost ten years later, Sungur & Tekkaya (2006, p. 310) had nearly the same definition for traditional instruction, "a lecture and questioning method," where the teacher provides information to the students and students are expected to answer teacher-generated questions. The limitation of traditional instruction is that students are not given a chance to demonstrate the knowledge and skills learned in class. Moreover, they are not given an opportunity to ask questions and discuss concepts for better understanding. It would be beneficial if traditional instruction incorporated group discussions and inquiry sessions in order to gain better understanding of difficult concepts.

Flipped learning, on the other hand, promotes a student-centered approach. Flumerfelt & Green (2013) stated flipped learning offers the promise of a greater extent of quality time in the classroom. Their reasoning was that in traditional instruction students are not as engaged as is possible with the flipped learning model. For example, in the flipped learning model, students watch a video lecture as homework and come to class ready to discuss and analyze the information learned in the video lecture homework. Passive learning activities are not a part of instructional time and this increases the available time for active learning activities (Flumerfelt & Green, 2013).

Flipped Classroom	**Traditional Classroom**
Video lectures are watched by students outside of class	Students listen to lectures in class and do assignments for homework
Projects, discussions and exercises are done in class	The whole class learns the material at the same pace, supposedly

Classes are structured in a workshop format to give students opportunities to question the teacher or classmates about the videos and materials	Students collaborate with each other on their own time outside of class

Studies have shown that flipped classrooms can significantly improve educational outcomes when compared to traditional classrooms (Grove, 2011). The efficacy of flipped classrooms and active learning strategies are well documented in the literature (Strauss, 2012). Additionally, Finkel (2012) conducted a survey of 452 teachers who flipped their classrooms, 67% reported increased test scores, with particular benefits for students in advanced placement classes and student with special needs, 80% reported improved student attitudes and 31% reduction in mathematics failure among ninth grade students.

Mathematics Student Engagement

According to Prenzel (1992) learning can be generated by personal relevance, which leads to cognitive engagement (Richardson & Newby, 2006; Ritchart, Church & Morrison, 2011). Specifically, students learn best when they are actively engaged in the learning process. A student's level of engagement is deeply influenced by the value they place on the content to be learned, and the value students place on instruction is clearly a result of the personal relevance they experience through the content. With the introduction of technology-based instruction such as flipped learning, these concepts have been blended into Engagement Theory (Frederickson, Reed & Clifford, 2005; Wishart & Blease, 1999).

The current theory of student engagement can be rooted in the experiential learning theory because of the concept of deep learning. Specifically, student engagement seems to be a three-dimensional construct that includes behavioral, emotional and cognitive engagement (Bonwell & Eison, 1991; Fredericks, Blumenfield & Paris, 2004; Wilson & Gerber, 2008). Rotgans & Schmidt (2011) suggested students being involved in learning tasks, effort, and class participation represents behavior engagement. Emotional engagement includes the affective reactions to peers, teachers and the classroom. Cognitive engagement involves investment in learning, learning goals, and planning (Ritchart, Church & Morrison, 2011).

By partaking in the active, learner centered environments, students commit to understanding the material by applying knowledge in real world situations, reflection, and experiencing what they have learned firsthand. Student engagement in the framework of learning is frequently stated to as a condition in which the student is motivated to develop meaning about their experience and willingness to put forth sustained effort to that end (Rotgans & Schmidt, 2011). Moreover, student engagement is considered to be among the better predictor of learning and personal development for students (Roehl, Reddy & Shannon, 2013). The more students study a particular subject or topic the more likely they will learn about it. This is referred to as "time on task." Even though engagement is not the same, it may equate in more time on task activities. Being engaged enhances students' skills, motivation and satisfaction with their own performance (Bodie, Powers & Fitch-Hauser, 2006; Bonwell & Eison, 1991; Ritchart, Church & Morrison, 2011).

The research on student engagement has led to gains in student achievement (Collins, 2014). For example, Fredericks, Blumfeld, Friedel, & Paris (2003) argue "there is considerable evidence in the research literature between engagement and positive academic outcomes." In a meta-analysis compiling the results from over 75 separate studies, Marzano (2007) shows that students in highly engaged classrooms outperform their peers by an average of almost 30 percentile points. However, the study participants recognized that engagement goes beyond grades and achievement scores. For example, Taylor stated that flipped learning allowed students to be more engaged which resulted in almost no behavioral problems in her classroom. She stated, "my students have stopped being disruptive since I have been using flipped learning," she went on to say, "they are more engaged in the activities and less inclined to mess with other students."

Butt (2014) states engagement is the students' depth of interaction, physically and cognitively, with the content. Outside of class, this takes the form of watching podcasts, assigned readings, small discussion posts, and small quizzes. In class, engagement with the content takes the form of small and large group discussions, research, problem solving, and project creation. Gaughan (2014) wanted to see if the increased student engagement would increase enrollment. In her qualitative study of 36 students, she spent the summer creating videos for her class and developed more engaging in-class activities, many of which included small group discussions. She conducted a survey at the end of the semester, but only 63% of her students participated in the survey.

In all of the studies reviewed, it was evident that the overwhelming majority of students and teachers perceived that there was more engagement with the information in a flipped classroom versus a traditional class (Findlay-Thompson & Momburquette, 2014; Murphee, 2014; Strayer, 2007; Wiley & Gardner, 2013). Lemmer (2013) attributed this to the concept of informed learning, which includes, "using information, creatively and reflectively in order to learn. It is learning that draws on the different ways in which we use information in academic professional and community life, and it is learning that draws on emerging understandings of our varied experiences of using information to learn" (p. 475).

Numerous research studies have illustrated that student engagement is linked to positive learning outcomes like critical thinking and achievement (Roehl, Reddy & Shannon, 2013). The interaction between motivation and interest is an important distinction as students can be motivated about learning and school but disinterested in topics and tasks (Fredericks, Blumenfeld & Paris, 2004). A high level of student engagement involves a combination of directed motivation and sustained effort in a learning environment (Appleton, Christenson, Kim & Reschly, 2006; Morris & Hiebert, 2011). Wiley & Gardner (2013) stated student engagement can be defined as the level of participation and intrinsic interest that a student shows in school. Engagement in schoolwork includes both behavior and attitude. Thus, engaged students seek out activities, inside and outside the classroom, that lead to success or learning. They display curiosity, a desire to know more, and positive emotional responses to learning and school.

The challenge of creating attention grabbing lessons that will hold the mathematics student's attention is faced consistently by teachers. Students must be provided with meaningful and challenging mathematics assignments on a regular and consistent basis. When students actively participate in their learning, they develop deep content knowledge, extend academic and life skills, and develop habits of minds that extend beyond the educational setting (Cuoco, Goldenberg, & Mark, 1996). As a result, the level of student engagement has been a focal point of mathematics instructional reform over the past decade (Lage, Platt, & Treglia, 2000).

Existing research has discovered that student engagement is influenced by the relevance of instruction, perceived student control, instrctional format, age, gender and subject matter (Shernoff, et. al., 2003). The traditional instructional format still remains the most prominent instructional method which places all of the control on the teacher. While an argument can be made that traditional instruction has its advantages, it is typically transmission oriented and for the communication of lower order knowledge (Halvorson, Jarvis, Johnston, & Sadeque, 2014). Nevertheless, when group work is compared to individual work, students are engaged the least during lessons that use the traditional instructional method of lecturing (Dolezal, Welsh, Pressley, & Vincent, 2003). Disengagement can stem from irrelevant, out dated, unchallenging curricula, and student tasks (Shaftel, Pass, & Schnabel, 2005). Also, transmission based approach of traditional instruction lacks long-term retention of key concepts and application of concepts in real world situations (Bacon & Stweart, 2006).

Class time was used differently in order to increase student engagement in the flipped learning environment. Although this was one result of flipped learning, another was an increase in the quality of instruction. Since the mathematics teachers pushed the front-loading of content outside of class, they were better able to design lessons that utilized the allotted class time for activities that reached the higher levels of Bloom's Taxonomy more regularly and consistently. Lemmer (2013) states "students report greater academic gains and teachers report greater professional gains when the course emphasizes analysis, synthesis and higher order learning approaches" (p. 480). When students engaged with information on a deeper level more often, this increased students' perception of the quality of the mathematics class.

In addition, the flipped learning environment allowed students to be more efficient with their learning of mathematics. By organizing the mathematics content to be accessed outside of class, students were able to move through the mathematics content at a pace that was suitable to them and their learning styles. A student had the opportunity to choose what to use and how often. Morin, Kecskemety, Harper, & Clingan (2014) conducted a mixed method study in an undergraduate engineering course using flipped learning with over 375 students and it found that the majority of the students found the delivery of the content to suit their learning needs. One student responded, "All the completing tutorials and working pre-assigned problems have been the most helpful to me because it made me actually want to do the pre-assignments and gave me material to look back on later that I could actually use as a guide" (p. 8). In addition, by making the content easily accessible, students had the opportunity to choose to opt out based on their cognitive abilities.

Several benchmarks of engaged learning can aid instruction and sustain an understanding of what students need in their educational experience in order to maximize the learning process (Zayapragassarazan & Kumar, 2012). Engaged learners are responsible for their own learning. They are typically self-regulated and recognize their own achievement goals. They choose tasks that are complicated. Performance-based assessments are usually used in generating performance criteria for students. The most powerful models of instruction are those that are interactive for students. It engages the learners and encourages them to construct and produce knowledge in a way that is meaningful and useful to them. The role of the teacher in the classroom has shifted from the information giver to that of a facilitator or guide. The teacher provides the interaction for learning experiences to occur through collaboration. One of the most important student roles in engaged learning is that of an explorer. Interaction with the real world and with other people allows students to discover concepts and apply the skills they learn. Students can then reflect upon the discoveries they make and the various experiences they have. This action is essential for the student as a cognitive apprentice. Another way to engage the learner is to take basic courses such as math and develop math assignments and connect to a major such as engineering.

There are some factors of engagement that instruction cannot change. For example, since the 1990's there have been changes in cultural and technological conditions (Wilson & Gerber, 2008). Also, a combination of factors, which may include socio-economic status and students' personal beliefs related to achievement, may impact engagement. This catapults into Windham's (2005) recommendation that, to engage learners in learning, educational curriculum and activity must include: Interaction, Exploration, Relevancy, Technology and Instruction (p. 5). Various elements of Windham's (2005) list are common among other researchers (Barnes, Marateo, & Ferris, 2007; Claxton 2007; Dunleavy & Milton, 2009; Hay, 2000; and OECD, 2008) to name a few.

A unique balance of challenge and skill are required on the part of the teacher to maximize student engagement (Driscoll, 2012; Hake, 1998; Prince, 2004; Talbert, 2014c; USDOE, 2008). Teachers must create assignments that offer appropriate challenges that enhance students' current skill by connecting to prior knowledge and provide timely student feedback (Shernoff et. al., 2003). Rather, academically stimulating tasks are created and executed in such a way that affords students the opportunity to concentrate fully on the task, while providing high levels of interest and enjoyment that will aid in the reduction of frustration and complacency by the student which leads to disengagement. According to a study conducted by Rowan-Kenyon et. al. (2012) students at all levels prefer lessons that are visually engaging and that allow them to work collaboratively with their peers.

Summary

Mathematics at the high school level is facing many challenges. The challenges are arising during a time when most researchers believe that students are going to need stronger mathematical skills than ever before in order to compete in the workplace (Mazur, 1991; NCTM, 2000). Many students are unprepared for high school mathematics and attempts to find better ways to help all students learn the mathematics they need to obtain educational and occupational goals are under way (Brewer, 2009; Cangelosi, 2003). Informed learning focuses on using information to learn and the students' awareness of that information as well as their ability to navigate it (Lemmer, 2013). Students in a flipped learning environment are to be more actively engaged with the information and perceived the content to be more meaningful. By actively engaging with the information, students can deepen their informational literacy skills (Lemmer, 2013).

Typically, high school mathematics instruction has been built around the lecture model (Cangelosi, 2003; Cobb, 1988; Ellis & Berry, 2005). In this teacher-centered approach, the instructor spends most of the class time lecturing, answering homework questions, explaining the rules of mathematics, and working numerous examples. This instructional method has secured its reputation because of the nature and amount of mathematics content covered in the classroom (Ellis & Berry, 2005; Riordan & Noyce, 2001). However, other pedagogical approaches are being explored because of the high rate of failure using the traditional pedagogical approach (Greenberg, Medlock & Stephens, 2011; Hattie, 2008). Many student-centered approaches are being used to promote more student engagement (Helping Students Climb to the Top, 2008; Milman, 2012; Tucker, 2012).

The flipped learning model came about from a confluence of video lecture first seen in distance education, inquiry-based learning principles, learning management systems, and learning technologies that enabled teachers to create their own online videos (Overmyer, 2014; Stigler & Hiebert, 2004; Tournaki & Podell, 2005; Uzun & Senturk, 2010). Most of the literature suggests that the flipped learning model is showing success, including success in college-level student achievement and mathematics. One common theme is that one of the most important aspects of the flipped model is not the videos, but the changed use of the face-to-face class time. However, this has not prevented some dissonance in the education community, as some critics may see the flipped model as a way to simply deliver content online to diminish the role of the classroom teacher (Pink, 2010; Overmyer, 2014). It should be reiterated that a flipped model does not change the amount of face-to-face time that a student spends in a classroom when compared to a traditional classroom.

Flipped educator's caution against blindly adopting the flipped classroom model without prudently considering the needs of their students (Bergmann & Sams, 2012; Hamden, et al., 2013; Berrett 2012). The flipped classroom represents a unique combination of active, face-to-face, inquiry based learning combined with direct instruction delivered asynchronously through online video (Bishop & Verleger, 2013). The rise in popularity and press on flipped learning has caused a synergistic rise in the publicity and implementation of the flipped classroom model. Likewise, it is the convergence of technologies that has taken place in past couple of years that has allowed for this innovation in education.

The evolution in educational technologies has driven the increased adoption of the flipped classroom model. Current mobile and Internet technologies bring a wider range of educational resources to the student, bringing a much richer experience to students (Overmyer, 2014). Additional advantages involve several facets of differentiated instruction. A classroom flip provides opportunity for active learning and student engagement through a wide range of hands-on activities, like individual assignments, discussions, problem solving, and critical thinking. In this scenario, the teacher functions as a guide and coach while students assimilate their knowledge through both individual and collaborative efforts (Project Tomorrow, 2011; Richart, Church & Morrison, 2011; Zerr, 2007).

Finally, flipped learning facilitates deep learning through providing opportunities for higher-level participation outcomes sought in the mathematics classroom (Bacon & Stewart, 2006; Berret, 2012). For example, students making comments and solving problems in a way that new insights to the equation are attained for both teacher and students in the class may foster deep learning and student engagement. As a result, flipped learning can provide the opportunity for students to achieve long-term retention and a greater understanding of concepts beyond rote memorization (Bacon & Stewart, 2006; Kadry & Abdelkhalk, 2014; Sophia & FLN, 2014).

Chapter Three

Research Design

The purpose of this qualitative study was to capture and describe mathematics teacher's experiences with the flipped learning model and the effectiveness, appropriateness and engagement of that model in middle and high school mathematics classrooms in Northwestern Ohio and Southeast Michigan. Although there is limited quantitative and qualitative data on flipped learning, a recent literature review based on teacher reports, course completion rates and supported methodology research indicated that flipped learning improved student achievement in classrooms across the country (ClassroomWindow & FLN, 2012; Sophia & FLN, 2012). However, research that delved into understanding how teachers perceive the effectiveness, appropriateness and engagement related to the use of the flipped learning model was very limited.

With the purpose of gaining an in-depth understanding of mathematics teachers' experiences with the flipped learning model, a research design that provided opportunities to observe and interview teachers who were currently using the flipped learning model in their mathematics classroom was used. Therefore, to meet the proposed criteria and adequately address the research questions, a qualitative study involving teacher interviews and participant observations was designed. Creswell (2009) defines qualitative research as a means for exploring and understanding the meaning that individuals and groups attribute to a social or human issue or problem.

Phenomenography was employed for this research study as it "is a research method adapted for mapping the qualitatively different ways in which people experience, conceptualize, perceive, and understand various aspects of, and phenomena in, the world around them” (Marton & Booth, 1997). Phenomenography is a qualitative orientation to research that takes a non-dualist perspective and is often used to describe the experiences of learning and teaching (Trigwell, 2000). This means that learning and teaching are seen as a relation between the person and the situation that they are experiencing (Bruce & Gerber, 1995). Phenomenography defines aspects that are critically different within a group involved in the same situation (Marton & Booth, 1998). It is these differences that make one way of seeing a situation qualitatively different from another. Phenomenographic research can unveil critical educational differences in the ways teachers experience flipped learning in the mathematics classroom.

The phenomenographic research approach

Marton & Pang (2005) states phenomenography was used as a research method first by a research group in the Education Department at the University of Gothenburg, Sweden. Phenomenography means descriptions of things as they appear to us (Marton, 1986). As a research method, phenomenography is premised on the principle of intentionality (Marton, 1986). This principle provides a non-dualistic view of human cognition that portrays experience as the internal relationship between human and the world (Marton & Pang, 2005). It strives to describe varied qualitative ways of experiencing various phenomena as a reflection of a persons varied ways of perceiving the world around them.

Phenomenographic studies have been used to address the variations in instruction and to develop pedagogy. For example, Crawford, Gordon, Nicholas, & Prosser (1994) looked at variation in the way students understood mathematics, Lyons & Prosser (1994) looked at variation in the way students understood photosynthesis, and Davey (2001) looked at the way nurses understood competency in neo-natal nursing. Each of these studies has had the extended outcome of informing change in curriculum to develop quality student-centered learning environments. More specifically, I used phenomenography to discover the qualitatively different ways, in which mathematics teachers experienced the various aspects of the flipped learning model in their classroom (Martin, 2006). According to Marton (1986), the object of research in phenomenography refers to variation in the ways of experiencing a phenomenon. Referencing recent developments in this approach, this variation personifies two faces (Marton & Pang, 2005). In the first face of variation, the focus is on the different ways in which people experience the phenomenon concluding in categories of descriptions and the outcome space. Certainly, it is the second order of describing a phenomenon in phenomenography (Marton, 1986). This focuses on how a phenomenon appears to or is perceived by people, which are contrary to the first-order, which is interested in searching for the essence and nature of a phenomenon (Marton, 1986).

The second-order perspective of explaining a phenomenon deals with the "what" variation and it is the first face of variation (Marton, 1986). It is intended to identify the differences people use when describing the phenomenon as it appears to them. The first face of variation is a traditional phenomenographic approach, which is simply descriptive and methodological oriented in which the researcher is the one to identify these differences (Marton & Pang, 2005).

Recent developments in phenomenography research extend beyond the first face of variation. Consequently, this approach seeks to identify "how" the variation comes to being. This is called the second face of variation. A phenomenon can be experienced in a finite number of ways qualitatively (Marton & Booth, 1998). Identifying these different ways of experiencing a phenomenon and how they evolve becomes crucial. This is because realizing the reason the underlying individual different ways of experiencing a particular phenomenon can aid in the understanding of the phenomenon in question. Marton & Pang (2005, p. 159) recognized that individual “variation corresponds to the critical aspects of the phenomenon.”

Increased concern over how people experience the same phenomenon in different ways resulted in the advancement of the variation theory (Marton & Booth, 1997). In this theory, Marton & Booth (1997) hypothesized that a way of understanding a phenomenon depends on how a person’s awareness of that thing is structured. Based on the Gestalt theory, the whole is made up of the parts. In order to understand a phenomenon, one must determine simultaneously its parts and the relationship between them. A phenomenon has both structural and referential aspects. Structural aspects describe something in its context and referential aspects provide the overall meaning assigned to that thing in its context (Marton & Booth, 1998).

The second face of variation provides conceptions with an ontological status, which implies the shift of phenomenography from methodological to theoretical concerns (Marton & Pang, 2005). Therefore, understanding variation in ways of experiencing the same thing among people transcends identifying categories of descriptions to theoretical framework underpinning those categories. I employed this phenomenographic approach so as to investigate the mathematics teachers’ differences in experiencing flipped learning.

Phenomenography and teaching

Marton's (1986) has been used to look at student learning and teacher experiences. Two studies in two separate countries were conducted by Marton & Pang (2005) to investigate teachers' experiences with literary understanding. The teacher experiences were categorized into understanding as a linear and vertical process, as a process of discernment and through variation. This shows the significance of phenomenographic research across country boundaries. In the current research, I found similarities between all rural, suburban and urban teachers, even across different grade levels and mathematical content areas.

Method

Initial analysis of the data resulted in me becoming familiar with the interview transcripts and observation notes. Each transcript was read and re-read numerous times in an attempt to reveal differences in the data which was referenced by Marton & Booth (1997) as "a pool of meaning." Notes were made with regard to commonalities in the mathematics teachers' experiences with flipped learning. Relevant quotes to the common categories were then extracted from the transcripts and observation notes and analyzed for their meaning. This afforded a means for decontextualizing the quotations from the individual respondent. Analyzing the quotes for their meaning was used delve deeper into the clarification and refinement of the categories and to reveal structural differences (how mathematics teachers experience the phenomenon) between the categories.

There were three major stages in the research design. First, a review of the literature was conducted to identify existing theories and research relating to flipped learning and mathematics teacher's experiences. Second, classroom observations were conducted before beginning the full study. The semi-structured interviews were the third and final stage. The study was conducted in an iterative manner where occurrences at later stages lead to a return to earlier stages. For example, data analysis led to a return to the literature review to find more literature on relevant themes as they emerged in the data. The classroom observations were used to determine whether the planned data collection and analysis methods would provide implications before beginning data collection for the study. The results of the data collection and analysis of the transcripts and classroom observations had implications for the study.

Design

Leedy & Ormond (2010) asserted, "research is the systematic process of collecting and analyzing information to increase our understanding of the phenomenon under study. It is the function of the researcher to contribute to the understanding of the phenomenon and to communicate that understanding to others." (p. 26). The focus of this study was dependent upon the willingness and openness of the participants to share their experiences and thoughts as they pertain to flipped learning. Therefore, multiple opportunities and different settings were provided for the participants to develop a level of comfort that promoted a willingness to share their honest perspectives.

Since the objective of this study was to gather data that provided a detailed look into teachers' experiences, it was important to use multiple data sources. For the purpose of this study, individual interviews and participant observations were utilized to collect data. As Morgan (1997) states, "in these combined uses of qualitative methods, the goal is to use each method so that it contributes something unique to the researcher's understanding of the phenomenon" (p. 3). The information that was obtained through numerous forms of qualitative research is believed to develop partnerships that will expand the richness of the data. It will be through the expanded understanding that the experiences of the participants will appropriately be captured.

Research Questions

In this phenomenographic study, the questions were designed to encourage participants to think about why they experience the phenomenon in certain ways and how they constitute meaning of the phenomenon. Therefore, the following research questions guided this study:

1. What are middle and high school mathematics teacher's experiences with the flipped learning model?
2. How do middle and high school mathematics teachers describe their experiences in increasing student engagement using the flipped learning model?
3. What contexts have influenced middle and high school mathematics teachers' experiences with flipped learning?

Participants

The subjects who participated in this study included six experienced teachers who are teachers in Northwest Ohio and Southeast Michigan. These teachers taught in rural, urban and suburban school districts. The schools in which these teacher's teach consist of approximately 2,500 students in grades 6-12. The age ranges of the participants will be from 28 to 66 years and include 4 females and two males. The teachers ranged in ethnicity to include Caucasian, Latin American and African American participants. The amount of teaching experience included teachers who have taught between six and 37 years. The minimum number of years of teaching experience was five.

The term “experienced” is defined as having five or more years of teaching experience (Elliott, Stemler, Sternberg, Grigorenko, & Hoffman, 2011). The participants were eligible for the study because they had five years or more of teaching experience in the field of education, specifically classroom instruction. All participants volunteered for the study. An email was sent out to all eligible participants inviting them to an informational meeting where the details of the study will be addressed. The teachers were given an opportunity to ask questions of the specifics of the study and will be given one week to respond. Signed participation and non-participations were turned in at the end of the week. The teacher participants met the criteria for the study and have chosen to participate in the study.

Setting for the Study

The teachers who were chosen for this study are from rural, suburban and urban schools in Northwest Ohio or Southeast Michigan currently using the flipped learning model in their mathematics classrooms. The teachers were selected based upon the grade level in which they taught, use of the flipped learning model, mathematics teachers, and years of experience. Research for this study was conducted via interviews and observations of six mathematics teachers in grades 6-12 who are using the flipped learning model and teach in rural, suburban or urban schools.

The student populations consisted of various racial and ethnic demographic groups. The schools ranged in socioeconomic status, as well, with two of the schools being considered a Title I school, which allows for extra governmental services to the school based upon its demographics and socioeconomic status. These particular sites were chosen for the study for several reasons. One was due to the willingness of the teachers to showcase their teaching of the mathematics curriculum using the flipped learning model and the desire from the administration for development of the staff using the flipped learning model. Secondly, the varied years of teaching experience by the teachers and the type of school in which they teach played another important factor. Finally, the convenience of the sites to perform observations of the teachers on multiple occasions was pertinent.

Procedures

Permission to perform the study was obtained from the principal of each school and Institutional Review Board. Letters and consent forms will be reproduced and dates chosen. The teachers were asked to volunteer for the proposed research project and signed a written consent form. Administration, faculty, staff, and student families were briefed and notified as to the specifications of the study, timeline, subjects involved, methodology, instructional methods, and procedures. The project sites were not ones with which the researcher had any past affiliation nor current relationship with; therefore, any potential researcher bias was not been considered. Additionally, since these are current mathematics teachers using the flipped learning model, no changes to the curriculum or instructional practices were necessitated.

Teacher observations and interviews were conducted on a weekly basis to ensure cohesion. These observations and interviews were conducted throughout the nine-week study to gauge the experiences of the teachers. Participants were able to choose the day and time of the observations and interviews. The qualitative approach was chosen for this study as the experiences of the experienced mathematics teachers was a reflection of how they understand flipped learning when used in their natural setting, the classroom.

After the interviews, all tape recordings were transcribed verbatim and field notes were typed for clarity. Coding categories were defined by specific thoughts, phrases or patterns (Bogdan & Biklen, 2007). This will allowed the descriptive data to be organized in a user-friendly format for further study and evaluation.

Data Collection

When using the phenomenographic approach to research, the data collection heavily relied on semi-structured interviews. The researcher formulated a few questions to focus the interview around the research, but successive questions emerged throughout the interview. Specifically, questions like, “What do you mean by that?”, “How did you go about identifying that?, or “How did it feel?” are asked to get a deeper explanation from the participant (Bowden, 2000). The participants eventually expressed the main essence of the phenomenon through levels of awareness of his or her capability. Ary et. al. (2006) describe this as reflecting from a state of “meta-awareness in which the participant is aware of their awareness of something” (p. 12). By collecting data from the participants using reflection journals and interviews, coding the transcriptions increased the outcome space. Triangulation and member checking were used to validate results.

Two interviews were conducted with all participants. The interviews lasted approximately 30 – 45 minutes with all six participants. Each interview included questions about instructional changes, implementation of flipped learning, and successes and failures experienced during implementation. Data were collected and analyzed from the study participants – reflection journals and interviews. I reviewed each data set in order to determine themes, lessons learned, and implementation processes and procedures. The first review of data was informational. What were the teacher participants saying about flipped learning? The second time I reviewed the data, I began to look for the big ideas or commonalities experienced by the participants related to flipped learning and their experiences. I began coding the data by circling and underlining commonalities. The third time I read the data, I began looking for commonalities between the big ideas. These common ideas birthed the themes of the study. Triangulation of the data described resulted in the findings reported in Chapter 4 and in the Implications for Practice identified in Chapter 5.

The final set of data from the study participants included in this study came from the classroom observations I conducted. The Classroom Observation Protocol was developed to collect the following: a) What was happening in the classroom?; b) Was there evidence of flipped learning?; c) What type of technology was available in the classroom?; d) Was the technology being used for flipped learning?; and e) Were students engaged in the learning process? The purpose for these observations was to see initially how the teacher participants conducted their classrooms, how they handle flipped lessons, and did they have the resources needed to implement flipped learning? I observed the classroom of all teacher participants myself. I recorded all that I observed during the time I was in the classroom. Each observation lasted approximately an hour. Therefore, the observations are subjective to what I say. However, I reviewed all observation notes and looked critically at what I documented during the observations.

Data Analysis

Phenomenography has not been applied to this kind of mathematics teacher research enough to establish a systematic step-by-step approach to data analysis. However, following the steps for generic qualitative data analysis (Creswell, 2009; Leedy

& Ormrod, 2010), all data were transcribed after the interviews and observations were conducted. The purpose of the analysis was to focus on the meaning that was found within the transcripts rather than hunting for evidence of predefined categories. In this sense phenomenographic analysis was interpretive and emerging. Therefore, the categories describing the mathematics teacher's experiences using flipped learning were developed on the basis of the range of responses observed in the transcripts. The transcripts were qualitatively analyzed and categorized, with a focus on similarities and differences in ways of experiencing and understanding the phenomenon of flipped learning.

It is important to note that although phenomenographic research is based upon the analysis of individual's experiences, the rationale is to create a description of experiences at the group level. More specifically, the result of the study is a categorical structure that describes the variation of experiences in a certain group of people. Therefore, in this study, phenomenographic research procedures were used with the purpose of revealing the various ways mathematics teachers experience flipped learning. Since results are presented on the collective level and one transcript is unlikely to relate exactly with the specific category, no solitary interview can be seen in isolation from the rest of the data (Akerlind, 2012). Each transcript was interpreted within in two contexts: (a) the context of the individual script and (b) the context of all transcripts (Akerlind, 2012).

Another important aspect in phenomenographic research is that it is a strictly data drive analytic method (Green, 2012). As a result, the categories formed during the analysis were not based on any pre-existing theory, but they were discovered from the data by the researcher (Akerlind, 2012). The analytic process mirrors that of Glaser

(2002) grounded theory. The primary difference is that grounded theory focuses directly on the nature of the phenomenon in question and the phenomenographic approach seeks to describe individual's experiences of the phenomenon instead of the phenomenon itself (Marton, 1986).

Coding techniques were implemented to organize the data from analysis of individual teacher interviews and determined the overriding themes that emerge from the various methods of data collection. Hahn (2008) emphasizes, "coding as an ongoing process of sorting and defining collected data that are relevant to your research purpose. By putting like minded pieces together into data clusters, you create an organizational framework" (p. 166).

Brammer (2006) stated phenomenographic research requires a decision trail for the reader to follow the steps taken during data collection, analysis and development of categories of description. The data provided many themes/categories, but only those duplicated themes/categories were chosen to be included in the results of this study. Decisions made by the researcher about themes/categories have been examined for any patterns between them.

A systematic analysis of data according to emerging patterns and participant experiences is reflected in the findings. Each of Parse's principles was used to examine the interviews and observation of the six participants and themes/categories of differences emerged and were discussed using excerpts of the data (Hobss & Bear, 1988). **TABLE 3.1**. Illustrates how Parse's principles and the research and interview questions were applied to the gathered data and analyzed for meaning.

Table 1 Parse's principles

Principle	Description	Data used to analysis findings	Data obtained from	Research question
1	Analysis of Meaning	Stories about education	Interviews	1, 2
	Analysis of Langue	Language used to describe	Interviews	1, 2
	Analysis of Imaging	Subjects & context of story	Interviews	3
	Analysis of Valuing	Assumed values of story	Interviews Interviews	1, 2
2	Analysis of Rhythm	Observations of teaching	Observation	1 – 3
3	Analysis of Interaction with students	Reported & observe interactions	Interviews & observation	2

In summary, the process of analyzing the data was repeated, compared and coded (Akerlind, 2012) in order to minimize my personal perspectives and to ensure reliability of the findings (Green, 2011). Overall, the phenomenographic data analysis can be viewed as a very meticulous and organized way of conducting qualitative research.

Ethical Reflection

This study examined the experiences of experienced mathematics teachers regarding flipped learning and use in the mathematics classroom. The experiences of these experienced teachers were the main focus of this study. These experienced mathematics teachers volunteered for the study and their trust in me, as the researcher afforded me the opportunity to have open communication and in-depth discussions. Precautions were taken throughout the study to protect the identities of the participants and each study participant was assigned a pseudonym to aid in the protection of the participants identity. All IRB protocols and procedures were followed to ensure the protection of each individual participant of the study.

I sought to improve the accuracy, credibility and validity of the recordings by using a quality control process called member checking (Doyle, 2007). During the interviews, I summarized information and then questioned the teacher to verify accuracy. The teacher either agreed or disagreed that the summaries reflect their views, opinions, and experiences, and the accuracy was validated, therefore, study is deemed credible (Creswell, 2009). The purpose of the member check was to reduce the frequency of incorrect or misinterpretation of data, with the goal of providing authentic and original results that will improve the validity of the study (Creswell, 2009).

Study Limitations

Personal involvement in flipped learning forced me to constantly evaluate and reflect on the data collected. Glesne, (2006) reveals, "Critical subjectivity involves a self-reflective attitude to the ground on which one is standing" (p. 126). Having an awareness of the "ground" on which the researcher stands is essential to keep at the forefront while conducting this research. The creation of this process afforded me the opportunity to constantly consider, inquire and assess the data from the participant's viewpoint.

Understanding the groundwork, configuration and purpose of flipped learning from my perspective afforded opportunities to develop more in-depth questions and insights for the research process. The structure of the interview questions and analytical questions allowed participants the opportunity to delve deeper into their experiences with flipped learning based upon their teaching experiences with both traditional and flipped classroom instructional strategies.

Summary

The purpose of this phenomenographic study investigated the experiences of mathematics teacher's use of flipped learning in the mathematics classroom. Experienced teachers participated based upon their implementation of the flipped classroom in their mathematics classrooms. After the nine-week observational period, interviews were conducted, taped and transcribed. Data was coded and emergent themes were documented and analyzed for significance.

In chapter four, emergent themes will be described, a descriptive overview of participants and a review of the research questions will occur. Then, in chapter five, I will address how the data and the organized emergent themes answered the three research questions that informed this study.

Chapter 4

Data Analysis

The data results presented in this chapter emerge from analysis of interviews, classroom observations and pre-interview questionnaires. Analysis of data was guided by the research questions. Response to question #1 requires a description of the qualitatively different ways mathematics teachers experience flipped learning in their classrooms. In order to describe qualitative variation in the ways mathematics teacher experience flipped learning in their classrooms, two additional questions were posed: Question #2 asks how the mathematics teacher feels his or her experience increases student engagement and Question #3 asks how the mathematics teacher feels traditional instruction relates to the experience of flipped learning.

In order to respond to the research questions posited in this study, the researcher adopted a phenomenographic approach to data analysis (Marton & Booth, 1997). Phenomenography seeks to describe the nature of variation in the collective experience of a phenomenon. Analysis starts by identifying patterns in the way in which a phenomenon is experienced. It then considers variation across patterns of experience to identify and describe the nature of the variation in experiences of a phenomenon. Variation in the experience of a phenomenon is presented in an outcome space representing the qualitative differences among patterns of experience. Phenomenography assumes that the patterns of experience are "stable and generalizable" (Marton, 1981, p. 177) across various situations, "even if individuals move from one category to another on different occasions" (Marton, 1981, p. 177). This study employs the phenomenographic approach to identify and describe variation in mathematics teachers' experience of flipped learning in their classrooms.

Given the philosophical underpinnings laid out in the previous sections, it is obvious that the majority of this research favors the use of qualitative methods to triangulate the results. In a sense, the methods were used in a hierarchical manner with the dominating method being the phenomenographic methodology employing the open and deep interview approach, which is carried out in a dialogical fashion (Booth, 1997). The primary method of investigation, the interview, is discussed first followed by the other methods of investigation employed in this study.

This chapter reports the findings of the main research question of the study: What has been the experience of mathematics teachers who have adopted the flipped learning model for their classroom based middle and high school classes? Findings are organized according to the sub-questions presented below:

a. How does the mathematics teacher feel his or her experience increases student engagement?
b. How does the mathematics teacher feel traditional instruction relate to the experience of flipped learning?

As might be expected in a transition process, much has changed for these instructors. The issue of change is woven into the discussion of most of the data analysis for this chapter. In order to address this question completely, a preliminary question was identified: How does the mathematics teacher discuss the changes to their teaching practice? This preliminary question will be addressed after the data on the original three questions are presented.

Demographics and descriptive participant data

As typical of a phenomenographic study, the participant set was not large. Six middle and high school mathematics teachers were interviewed and provided class materials for analysis. The following section briefly describes the demographics of this set. In addition, descriptive data on the content conversion methods of participants has been included as further introduction to the variety of practices represented. Although the data presented demonstrates the diversity of background and setting represented in the groups, the discussion in the following chapter will make clear the commonalities they share. The strong connections between this small yet diverse set of mathematics teachers underscore the value of this study's results as well as the need for further research into this phenomenon they have adopted for their work.

The teaching experience of the study participants range from five years to 35 years and their experience with flipped learning reaches more than 10 years to just one year. Their teaching experience has been at rural, suburban and urban school districts. All teachers teach at least three mathematics classes daily, ranging from Algebra 1 to Calculus. Class sizes range from 15 to 25 students. In keeping with the study requirements, all participants have previously taught using a more traditional classroom model. Also, all have adopted a form of the flipped classroom as defined for the study.

The six participants provide online content for their students. The mathematics teachers typically use their own podcasts and they may provide access to some content from vendors or online repositories like YouTube, TeacherTube or Khan Academy. The podcasts vary in length from 3 minutes up to 45 minutes. Some are simple screencasts, slides with text and images, and others use a lecture-capture system to record a video of the mathematics teacher presenting a lecture or working out problems on a whiteboard.

Though the mathematics teachers who chose to participate in this study volunteered, it was important to acknowledge any risks associated with participating and to ensure that appropriate considerations were in place for the study participants. An application to the Internal Review Board (IRB) at the University of Toledo was an important component of this study. Human subject research is guided by federal policies and procedures that help determine funding of research projects. According to those guidelines, research is eligible for exempt status when it takes place within an educational setting and addresses issues of instructional strategies. Therefore, this research study qualified as exempt research.

Several steps were taken in order to address and minimize risks for study informants. Each participant was provided with and asked to review an informed consent form confirming their understanding of the study and the role they would play in it. This form provided them with an overview of the study, its goals, expectations of the informants, and information on confidentiality, risks and benefits of the study. Each participant signed a form at the beginning of the interview and they were emailed a copy of the form per their request.

Every effort was made to address study participants questions prior to the interviews to confirm their participation in the study. In order to protect the privacy and identity of study participants, the study has been reported without using actual names, and other identifying information was excluded from the study results. In addition data collected has not been shared with anyone but the source of the data during this study, and will remain confidential. All study documents have been stored securely during the course of the study and will be destroyed, per protocol, three years after the study. These steps were intended to make participants in the study a positive and protected experience for all study participants.

Meet the mathematics teacher participants

Bill

Bill is in his late fifties, in his fifth year of flipping his mathematics classes at a suburban high school in Northwest Ohio. He has undergraduate and graduate degrees in education. According to Paul (2005) “available research supports a belief that a high quality mathematics education for high school students cannot be accomplished unless a highly qualified mathematics teacher is in the classroom” (p. 456). He is the most senior participant in the study. When asked about his background in teaching, Bill indicated that he has been teaching for almost thirty years in predominately white and upper middle class suburban school districts. This school serves grades six through twelve. The school is 74% white, 15% African American, 5% Hispanic/Latino, and 6% other. The school has a total of 43 teachers servicing a total of 582 students with 36% of those students receiving free/reduced lunch. Each student has an iPad and the school has Wifi, which is available to all students and staff.

Bill used to teach using traditional instructional strategies until he felt “like he needed an educational shift.” He went on to say that he felt like teaching was becoming boring and he wasn’t enjoying it as much as he did ten years ago, which is why he switch to flipped learning. During my interview with Bill, he explained how he initially flipped his classes. He stated, “I had my students watch a ten minute video on the intro to flipclass and they were required to take notes and ask one question. The next day in class they went back over the homework for the chapter, the supplies they needed, take my number down, and show them how to sign up for Edmodo. He continued stating, “We reviewed the flipclass video and answered an burning questions, discussed expectations and how to watch a video for education and not entertainment.” I thought this was an excellent way to introduce a new instructional concept to students and to get buy in from them too.

Bill shared his flipped learning outline with me prior to the students entering class. The outline was a lesson on linear functions. It included at least one learning target that included an “I Can” statement. It outlined the expectations for each lesson. For example, students were to watch videos or read specific page numbers, take notes, complete the “check it out,” practice several problems and optional practice problems were identified for students who might need extra practice. At the end of the third lesson, students were prompted to complete a concept check over the previous three lessons with a set deadline and instructed not to move onto lesson 4 unless they successfully passed the concept check.

Bill’s flipped class seemed to foster a more student-centered learning environment. What was traditionally done during class was changed to take place outside of class time in an online environment using the learning management system Edmodo. Video lecture lessons, online quizzes, and practice problems were posted in Edmoso and students were instructed to preview the content prior to class as their homework. According to Bill, “moving the content delivery from class time provided more time to have content discussions, group learning activities, practice time, and assessments during class." During my observation, over ninety percent of the class time was devoted to the facilitation of discussions, collaborative activity problems, and the completion of assignments and assessments.

An open-ended activity problem used during my observation was the Barbie Bungee activity (NCTM, 2008). During the activity, students were instructed to create a bungee jump for a Barbie doll. Students were in random groups were given rubber bands and a doll and were asked to predict the number of rubber bands required. The objective of the activity was to give Barbie the greatest thrill without hitting the floor. Students had to conduct the experiment, collect data and then use the data to predict the maximum number of rubber bands that should be used to give Barbie a safe jump from a height of 400cm. Eventually, through discussion, students noted the linear relationship between the number of rubber bands and the measure of the doll's descent, which led to further discussion on linear equations and slope. This was a fantastic lesson.

Students also completed student-generated examples during my observation. These are examples that students generate for purposes of involvement in the learning process. Every student was asked to write their equations on the board and since the board wasn't large enough, on the windows. Each equation was briefly discussed. One example of a student-generated example problem was:

$$3(132x - 126x) - 17x + \sqrt{200}/2 = 25$$

The initial discussion started with the question – what is an equation? What do equations look like? What does it mean that a mathematical statement is semantically correct? They discussed the differences between false mathematical statements, equations with one solution, two solutions, an infinite number of solutions and no solution. They then began classifying the equations around the room and tried to figure them out, before they began to solve them, which equations were easier than others. The students became more confident answering questions in a manner they had not previously experienced and different from the textbook.

Finally, Bill encouraged engagement and understanding and it was evident based upon the manner of grouping students. He grouped students so that they would productively collaborate. It was evident the in-class workload and the out of class workloads were flipped as compared to a traditional mathematics class. Class time was used to provide students with opportunities to engage with collaborative problem-based learning tasks, a facilitative teacher, and a variety of learning tools.

Kennedy

Kennedy is a female in her early thirties who has been flipping her Pre-Calculus classes for three years. She is currently in her fifth year of teaching and teaches in a small rural high school in southeast Michigan. She has a degree in mathematics and obtained her teaching certification while working as a long-term substitute teacher. She enjoys teaching here (rural district) because it’s what’s familiar to her, as she grew up in rural Nebraska.

Her school is located in a rural part of the state where unemployment is high and the workforce is largely reliant on agriculture and small-scale manufacturing. For many students in her class she is the link to their understanding of the world beyond their small Michigan county, one that requires her to make constant judgment calls about the scope of what she teach. On the other hand, one of the innate benefits of working in a rural setting is the strong sense of community that’s pervasive throughout the school. She states her “greatest reward in her tenure as a rural educator is to walk the halls and see kindergartners walking alongside high school students.”

Upon the conclusion of this school year, Kennedy wants to begin coursework to obtain a doctorate degree in Higher Education. She hopes to begin coursework this summer, but would be okay with waiting until the fall.

Kennedy teaches pre-calculus has 64% Caucasian students, Hispanic students represented 32% of the population and African Americans totaled 4% of the population. She used different instructional strategies such as, PowerPoint, lecture and direct teaching. There were numerous hands on activities that required students to take ownership of their work. Whole group learning also took place during the lesson.

Kennedy stated, “ Last night my students had to read two sections from the textbook that I had not taught. They had to complete a few lesson practice problems and I had optional assignments for students who wanted to dig a little deeper.” She further stated, “In class the next day I will check with students independently to make sure they were okay with the homework. I will assign each group a problem to present and while they are presenting I will access whether they have understood the content through questioning techniques and discourse.”

The classroom atmosphere was congenial and the students were actively engaged in discussion. The teacher has clearly developed a format where students participate in authentic discussion and understand their accountability to the discussion and their peers. The learning environment is impressive for an upper level course in rural community. The student’s seem to enjoy being in the class and nearly all students are working hard.

It is evident that the students appreciate the chance to be engaged in “real” problems and analysis of complex situations and “what-if” scenarios that challenge them to think.

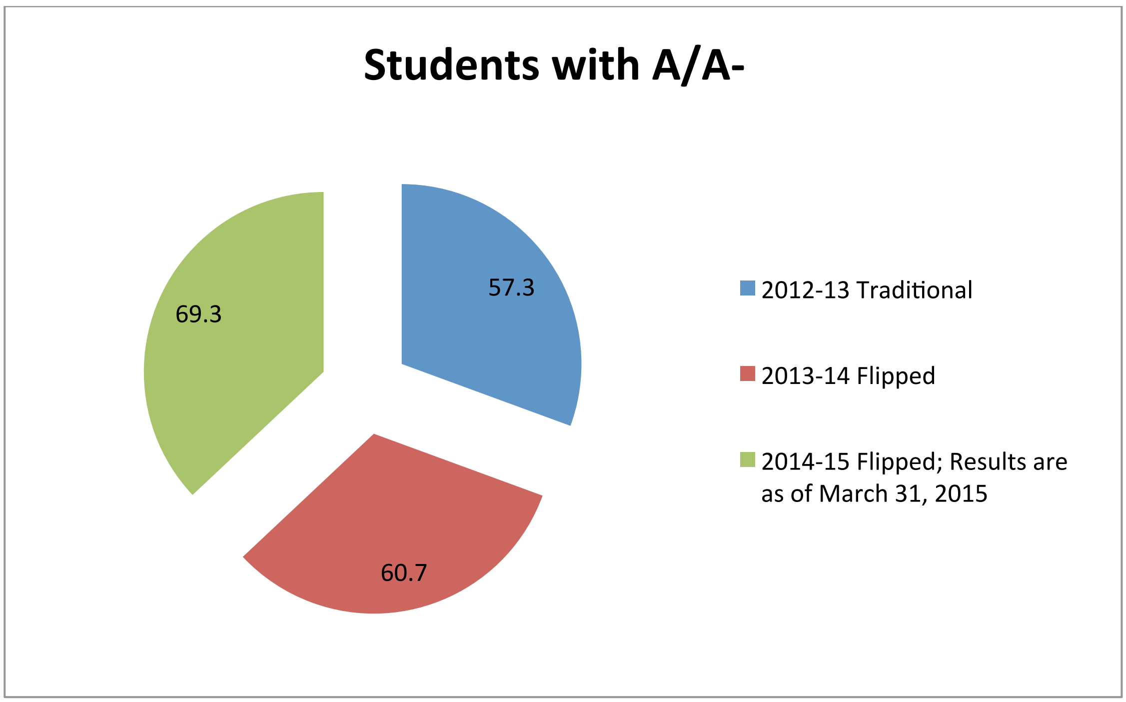
She began with whole group then broke the students up into smaller groups to work amongst themselves while monitoring and giving feedback to the various groups. This was followed by a PowerPoint presentation that involved lecture to aid with students visualization of what the teacher was saying be following along from their PowerPoint notes. The different strategies were used to keep the students engaged in the learning and provide them with different ways of learning the material. For example, students were able to ask questions and felt free to do so.

Students were allowed to respond and correct their mistakes. This aided in effectively reaching students and promoting student learning and success. Kennedy stated then she activated the lesson by holding up an object that related to the days lesson. Then, she demonstrated some problems because students made it clear that they want to watch her solve some problems and then groups will explore the content through active learning strategies. She further stated, “we will pose some more challenging problems that students have assistance to solve and at the end of class they’ll demonstrate that they’ve learned the content through exit slips and assessments.”

Kennedy also promoted relationship building and respect for ideas of each student by positively reinforcing students’ responses to her questions and asking the students to work together on a number of tasks. Additionally, she had students discuss with their neighbor answers and predictions they had concluded based on the instruction. While students discussed their answers with one another, Kennedy moved around the room, observing and offering encouragement to the teams. It appeared that all students were anxious to share their ideas with their neighbors and really listened to the other student's response. They were definitely engaged with each other and the assignment as well as the conversations related to the subject matter.

Graph 4.1 shows that 68.3% of her pre-calculus students are earning A's and A-"s with the flipped classroom methodology compared to the traditional lecture methodology.

Graph 4.1: Kennedy's Pre-Calculus Students with A/A- grades



<u>Mark</u>

Mark is a male in his early thirties who was in his second year of flipping his mathematics classes in a rural school district in northwest Ohio; however, he spent most of his life in the city before becoming a rural educator, three years ago.   He has a degree in middle school mathematics education. He has been teaching for eight years and flipping for two years. He states that he loves the fact that he has been given an opportunity to be a leader in his community. He says working in a rural community has allowed him to quickly develop meaningful relationships with parents and community members.

At the time of data collection, Mark was teaching all sections of the geometry courses at his school. He completed his alternative certification program in the summer of 2005 and plans to pursue his Master's of Education in Mathematics Education.

Mark speaks clearly and articulately about the geometric concepts. The objective of the lesson was clearly articulated. He uses a combination of PowerPoint and the whiteboard when delivering most of the lesson. He advances through problems and concepts, bullet by bullet on each slide then moves to the whiteboard to write examples. His room is arranged in a manner to allow students to work with the person sitting next to them with ease or to work in groups of four with the pair in front or in back of them. One student sits by himself in the front and one by herself in the back.

During my interview with Mark, he explained that he flipped his classes to make the most of his face-to-face time with his students. He stated, "I was not able to meet the needs of my students when I spent the majority of class lecturing. I was unable to differentiate instruction, so only a fraction of my students were learning." Mark had a very different approach to the flipped classroom. He stated that he initially planned to assign videos each night, but now "I never assign anything, students self-pace themselves up to a test deadline. I initially planned to have students take their quizzes in a traditional manner, now students collaborate and take them in groups so they can help another and have conversations through."

He uses strategies to deliver instruction that meets the needs of the numerous learning styles by repeating vocabulary. He used guided practice to lead students through a problem and show them what to do in a few examples. Additionally, he used non-examples to clarify when not to do something, to help reduce some of the misconceptions they had about the assignment. Students engage with the learning through seeing problems, listening to problems, practicing individually, practicing in pairs or small groups, and reviewing as a whole class. At times, when students are working on practice problems, Mark walks around the room to answer questions. The teacher-student interaction was phenomenal. There was clear evidence of teacher-student rapport. He also encourages students to get help from each other. Although the classroom lacked a classroom set of computers, Mark was multitalented. He was a facilitator, a controller, a checker, and a guide who circulated from group to group asking probing questions and answering student queries. He does formative checks to see if all students understand the concepts shared in class by checking the homework as a whole class. Transitions between tasks were made smoothly that students were engaged in the activities assigned to them. His students appear to be on track and focused. There are no student behavior problems or students asking to leave the class.

Altogether, Mark's lesson was very successful. He utilized instructional strategies that were aligned with the lesson's objectives. Classroom interaction, instructor's directions, his explanations, his introduction of skills in the appropriate sequence, his monitoring of student tasks, and his adequate seating arrangement and time management skills all constituted evidence of success. However, a more effective use of the whiteboard will most likely aid in achieving better outcomes.

<u>Melissa</u>

Melissa is in her late thirties and has been an urban educator for eleven years and flipping for three of those years. She has an undergraduate degree in business. Before teaching she worked at an automotive plant in human resources. She decided to go back to schools and earn a master's degree in education.

Melissa said she still has the occasional student who'll put his head down or surf the Internet instead of working, but giving students some control over the pace of their learning improves their desire to learn. Misbehavior all but disappeared after she flipped the classroom, she said, and students who hadn't passed anything in years began proudly displaying their grades. She has stated, "They are getting to choose to push the play button. They were very excited about accepting that responsibility. They actually like having the power to make decisions. That's the biggest impact I've seen in my classroom. The ownership has shifted from the teacher to the student."

I observed Melissa's geometry class, which is comprised of 17 students. The student's are arranged in groups of four in an "L" shaped pod, to allow them to see the whiteboard and still be able to discuss content as a group. The class began with the student's independently checking their work. The teacher had a copy of the answers, which she displayed on the whiteboard using a document camera and an Epson projector. Students were able to ask questions once the assignment had been checked. The teacher worked through 2 problems, #17 & #18, and then when there were no questions, requested the assignment was collected.

The outside of classwork was for students to watch three videos on the investigation, justification, and application of the isosceles triangle theorem and its converse. After students watched the videos, they were to respond to the posted question in Edmodo before coming to class and complete the worksheet. They were also instructed to take notes and turn their notes in at the end of the week. In-class the teacher interacted with the entire class. In-class students had a bell ringer assignment. While students were working on the bell ringer assignment, the teacher checked student note taking worksheets for completeness and reviewed student questions. After about ten minutes, the entire class reviewed the bell ringer problems and the teacher acted as the facilitator.

During class, the teacher worked with small groups and individual students as needed based upon questions from the homework and some students were able to review the video assignments, if necessary. Some students worked with a partner or in small groups to share and discuss concepts. These students were on target and had mastered the bell ringer and homework. In addition, these students completed problems assigned by the teacher using the 30-60-90 or 45-45-90 rules worksheet, posted in Edmodo, the online textbook or posted on the board. Students were also given the option to use the Geoboard or Sketchpad app. At the end of class, students had to write a comment on two other student's posts from the daily question in Edmodo.

Melissa showed competence in her mathematics content knowledge and this was evidenced throughout the lesson as she used instructional strategies that were appropriate for this lesson. She used whole and small group instruction, instruction with technology, instruction to meet multiple learning styles, and instruction with guided practice. Melissa also used strategies that engaged all students. She grouped students to promote collaborative learning pods and chunked instructional practices between whole and small group instruction. Also, she used research-based instructional strategies that addressed the full range of cognitive levels, through the use of whole and small group instruction, instruction with technology, instruction to meet multiple learning styles, and instruction with guided practice.

She had a classroom management plan like I've never seen before. On a space on the whiteboard she had a category marked "Homework tally," where students indicated problems they got wrong and want to go over at the beginning of class. She also had problems assigned each day of the week written in the same place each day on the board. Finally, Melissa was able to adjust instruction to meet students' needs to include manipulatives so students see the proof of three angles totaling 180 degrees and she tied the proofs to past learning experiences.

<u>Taylor</u>

Taylor is a female in her early thirties who was a sixth year, full-time teacher at a suburban high school in Northwest Ohio. She flipped her mathematics class for the first time this year. When asked about her background in teaching, she explained her history both regarding education and employment. Taylor has a degree in mathematics and sought to become a teacher. She decided to flip her class because she wanted to increase her student's math scores. Since flipping, she has been able to work individually with each study. She said, "students are able to pace themselves better and work with me on a one-to-one basis." She also said she likes the idea of incorporating higher order thinking problems and students are engaged.

Taylor's students had to watch a video the night before that taught them about inequalities. Students were expected to fill in their Know-It-All notebook during the video lecture and work on questions posed during the video. Students were reminded to check the class website, which is where the video was posted for them to watch. Taylor said that she attempts to limit the runtime of the video to ten minutes or less. For those students who did not watch the videos and complete the assignment, they were required to complete the assignment while serving after school academic detention. Taylor also stated, “This is highly recommended for those students who are behind in their work.” She further stated, “This is not designed to be punitive, but is instead a way to ensure the student can demonstrate mastery of essential mathematical skills.”

I observed Taylor’s 7th grade Algebra 1 class. During the observation, students were split into 4 subgroups and rotated through four activity stations based on the lesson. Students worked together to complete each activity. The teacher circulated to assist or intervene as necessary. The teacher also set a timer that prompted students to switch stations every ten minutes. Here are the four activities:

1. Using random value generators on the iPad, students will be given a point and slope. Using the values, they will write an equation of a line in slope-intercept form. A total of three equations must be written.
2. Students will be given the graphs of two lines. Students will find and write the equation of each line in slope-intercept form. (Note: Students will need to incorporate prior learning of calculating slope using the graph of a line or two given points on the line).
3. Using a random value generator on the iPad, students will be given the coordinates of two points. Using the two points, students will write an equation of a line in slope-intercept form (students must write two equations). (Note:

Students will need to incorporate prior learning of first calculating slope using two points on the line).

4. Students will be given three completed problems, showing all of the steps of writing the equation of a line in slope-intercept form, including one calculation or substitution error in each one. Students will be asked to find the error and either fix it or explain what makes the problem wrong.

Lastly, students were assessed by creating a video using Sophia in where they had to demonstrate (while explaining) how to write the equation of a line in slope-intercept form. They had to show two complete problems, using their own slope and coordinate values and the other using two points of their own choosing. This was a great way of using different types of strategies to differentiate instruction and use of technology.

Taylor did keep a nonjudgmental attitude when she engaged with her students. She mostly walked around and questioned her students on their findings to make sure they were staying on task. If she felt that a group had sufficient information on how to graph inequalities she would allow the group to go to the front of the class and present. Most students were nervous about presenting but the teacher asked them questions to get them started and guide them through at the same time. The teacher gave 100% of her attention to her students and listened attentively.

The entire lesson was based on student-to-student interaction so it is safe to say the teacher motivated her students to listen, respond and question each other allowing them to work in groups and giving them the freedom to use resources to research a new mathematics concept so they were able to teach themselves and their classmates. Taylor utilized flipped classroom where instruction and new material were delivered via video and class time was used for activities and discussions that met the needs of each student.

Tina

Tina is a female in her late fifties who was in her thirty-second year of teaching at an urban high school in Northwest Ohio. She has a degree in mathematics education and has been flipping her classes for two years. When asked about her teaching background, she said she has been teaching in the same district her entire career and enjoys being around high school students. Over the course of tenure, she has observed teachers, taken education courses and acted as a mentor for new teachers.

In her class, groups of four students sit at tables discussing how to solve a particular problem, or stand at the whiteboard arguing about the best way to proceed. The teacher moves around the room talking with the different groups in turn, making suggestions as to how to proceed, or pointing out possible errors in a particular line of reasoning the students are following. Occasionally, the she will call the entire group to order and ask one group to explain their solution to the rest of the class, or to give a short, mini-lecture about a particular concept or method.

At the time of data collection, she was contemplating retirement, but decided she would not retire for another three years because since flipping her class she has been rejuvenated. Tina stated that all direct instruction is moved out of the group learning space and is given to students on video, so they can learn the basic content at their pace whenever and wherever they want. She stated, “This allows the instruction that is given to be more efficient and effective in achieving its purpose of helping students understand the basic content.”

Prior to observing her class, Tina and I conducted an interview and she explained the advantages of flipped classroom. She stated, "Flipped classroom allows me more time with students who are struggling and to help with their conceptual knowledge of mathematics." Through her interview, I found that flipped classroom has allowed her to use class time to see how much her students understand and apply the material. It's here that we can really see if students are actually learning and not just regurgitating the material."

Her class is structured around a concept called "WSQ." Before students come to class, they have to complete a WSQ, which means:

- ✓ Watch: They watch the video and take notes in their guided notes packets
- ✓ Summarize: They write a summary or answer guided summary questions found at the bottom of the video and send it to me
- ✓ Question: They write a higher-order thinking question about the lesson to bring to class the next day

She stated that the "WSQ" not only aids in holding students accountable for coming to class prepared and for processing the information presented to them, it also "allows us to begin class with a discussion and group activity about the lesson, focusing on student questions." Tina further stated that she has students' questions and comments prior to class because they have to send their questions and comments to her the night before. She said this helps her with common confusions students have and what needs to be the focus of the discussion. She stated that after the discussion, students are given opportunities for practice, peer teaching, student problem creation (they write and solve their own math problems in mini-videos and then post to their student blogs) and small group remediation.

From the start of the class the teacher had students arranged in groups of four. Tina was engaging with the students and conducting the chores happily during the class period; her face radiated at any student interaction. Tina was present throughout the entire class period. There was no clock on the wall and the class lasted 90 minutes. Students were enthusiastically focused on completing the mathematics problems.

Tina at one point noticed students were not paying attention to her. She raised her hand as a motion for silence. The students reacted and responded by adhering to the lead of the teacher's hand; specifically, each student followed with the same gesture. After all the students' hands were raised, Tina lowered her hand and began talking about the assigned problem.

The teacher then began to write a problem from the textbook on the whiteboard. It was a linear equation and asked the groups who had the same result as on the whiteboard. The instructions were to solve the variable of the linear equation of degree one. This is the simplest form of a linear equation known as a monomial. The problem was as follows: $4x + 10 = 30$. Therefore, the instructions were to solve for the variable "x" from the linear equation.

The students were very assertive in answering the question. None, of them made any error responding to Tina's problem selection from the textbook. Tina explained the reason her students are assertive when it comes to answering questions. She stated, "In my flipped classes, I have designed an environment were students feel safe to ask any type of question without feeling as if they will get ridiculed by their peers." For example, in gratitude and pride to her students' success, she also announced each and every one of the groups as super-heroes. For example, the group at the far right end of the row was named Flash Gordon and the one opposite of the same row, was named Captain America. At this moment, Tina provided clear definitions using mathematical language. Utilizing the terminology "integers." For all the numbers that consist from the far left, which are all the negative numbers and from the far right are all positive numbers. This includes the point called zero, which is the middle point of the left side of the negative numbers and the right side of the positive numbers.

The classroom arrangement was pretty simple. The back of the class has two whiteboards attached to their frames covered with several posters all alongside the whiteboard frame edges.

Tina provided assistance to guide the students to the right answer. One student takes notes whenever the other three students are instructed to write down the steps to obtain the correct answer of the linear equation.

After providing all the necessary assistance to the students, the instructor started to work several other problems listed from the textbook and put them on display on the whiteboard. She then reinforced the learning objective going over several other problems similar to the one stated previously. The teacher also had a few other problems she wrote at the side of the textbook, which she constructed.

Several students approached the teacher with their textbook to ask for questions related to the problems assigned. The teacher pulled a piece of paper from under her desk and started to apply the pressure to move his pencil, in a manner of guiding the student to follow some steps. Then, another student stood up, followed by another, until a line of students was formed waiting to be attended with their math books by the teacher.

Yet, the remaining students were not asking questions, however, they were engaged in the textbook problems. Other students were having a conversation about mathematics. And, a few were working independently. There is this particular African American student with short hair, who was seated at the far right of the row of desks under the super hero, Batman. She was independently solving the assigned problems. Whenever a problem wasn't understood, she would go around asking her peers who were able to understand the problem, for assistance.

During the solving of the linear equation, students did not have calculators, giving the impression that calculators are not allowed. The classroom environment was also not equipped with any technology either. One student from group Captain America volunteered to verify an answer when several groups were getting different answers.

Tina was engaged with her students and had a great deal of recreational moment (Rodgers, 2002). However, the lack of technology may be detrimental to the teachers' method of teaching. One weakness was her lack of differentiation. A seemingly strength is her approach to learning by repeating, where she motivated the students to answer assertively and believe in themselves by referring to them as super heroes (Rodgers, 2002). By using some flipped learning techniques, Tina was able to use her class time to fully focus on the students and provide opportunities for them to Think, Write, Interact, Read, Listen, and Speak (TWIRLS) mathematically.

How do mathematics teachers discuss the changes to their teaching practice?

The concept of adoption can suggest a contained implementation process that includes a starting phase of learning related to and committing to a change. The flipped learning model may evoke a type of narrative that the teaching practice had long been structured in one way, but the new model was discovered and adopted, resulting in a different but equally stable structure for the teaching practice. It could also be viewed that the design of this study was based in part on such an expectation, with its questions on influences, changes and challenges. This perception of change stands in contrast to the equally valid concept of continuous improvement. Continuous improvement involves a cycle that might include steps like assessment, planning, implementation and setting new goals (Hidden Curriculum, 2014). These differing perspectives can result in very different approaches to the discussion of an adoption process.

The ways in which the mathematics teachers described their experiences adopting this model reflected the description of a continuous process. For many, there was a clear point when presentation of content left the classroom or when content began to be posted online, but these were viewed as examples of many transition points in the continuum of change. Mark said, "I used to do in class activities once or twice a month before I flipped and students didn't like it. Now, since flipping my class I'm able to do some type of hands on activity daily. This really kind of got kids on my side and they got to seeing these kinds of activities as beneficial." For Bill, the transition to a flipped classroom started five years ago, but took place gradually. His classes only became completely flipped two years ago, when he stopped using any class time as lecture time. For Kennedy, this transition occurred in two major steps: removing lecture from class sessions came three years before she began posting content online. However, she describes the process as being “like revolution and then continuous improvement followed by revolution” (Gamble, Marsella, & Stone, 2007, p. 95). The practice of most of the participants continued to evolve over numerous years as they evaluated their teaching practices, observed their students’ learning experiences and worked toward improvement in their role as instructional leaders.

Tina described beginning to teach nearly 30 years ago, stating “I just feel there has to be more to this than talking at students and then giving them a test.” Over the course of her interview, she described numerous investigations, insights and changes she has made over the years, which she refers to as, “the continuing evolution of how to get students engaged and reporting what they have learned.” Steps along the way included take-home exams, many iterations of how group work was structured and presented, moving class content online, and rearranging the presentation of content to get students involved in problem solving earlier in the class. She also discussed specific challenges she continues to struggle with, like the question of how to best evaluate projects now that she has totally eliminated exam grading. She stated, “I have implemented some this things this year that I have never done before,” and one thing in particular she is “not satisfied that I’m doing the best job that I can.” This ongoing desire to improve, lasting over two decades, clearly demonstrates early adopter characteristics.

Other participants discussed their experiences in similar terms. Mark also emphasized that he has “slowly progressed into the flipped model.” He described how he “moved to project-based assignments and papers years ago,” in place of exams and how he transitioned from transparencies to adopting PowerPoint presentations for his lectures, to being able to post the presentations online for student access, to abandoning their use in class and telling students "to watch the PowerPoint yourself." Once he made that change, he found that, "All of a sudden I had a lot more time in class." That turning point then led to additional developments. Those developments ranged from transforming his presentation slides to interactive learning modules that combine short videos, links to web-based resources and self-assessment quizzes. He also spoke of his current change efforts, saying that he "has fifteen ideas that I want to execute right now."

Even the teachers who have had the shortest experiences with flipped learning described the transition as a series of changes. Melissa explained that she "made a lot of changes between year one and year two." She also said, "I started off my career ten years ago as a pretty traditional teacher moving through using cooperative learning to group work" until she discovered flipped learning. She further stated, "The first day I started flipping my classes the students and I stared at each other for thirty minutes before I could figure out what I was going to do with the "extra" face-to-face time." Taylor, who has the shortest amount of experience with flipped learning, "knew there were some steps she could take to improve her class." Now that flipped learning has been successful for her, she "will be considering adding more components to this model." Kennedy who conceived flipped learning on her own and implemented it almost immediately, discusses how her learning process that took place after flipping her class. She stated, "One of the things that came later was learning how students learned and how they are motivated." She describes attending a conference in Florida, where she saw varied examples of the uses for online tools, which assisted her in the development of her classroom structure.

Like Bill, Melissa and Taylor all used some form of group work on their way to flipped learning. Kennedy was inclined toward the use of a combination of strategies including having guest speakers, tours and live demonstrations in her teaching before being introduced to flipped learning. She stated, “I tried to mix things up, but it was still mostly me giving instructions: (I was the sage on the stage.”) Despite that predisposition, she transitioned gradually, over time. She stated, “We started where I actually did still continue to do some lecturing and we have transitioned away from that to less lecture and more student ownership.” She has only in three years applied “the most aggressive implementation of the flipped classroom, with no lecture.” Her transition period included the development of course materials, including co-authoring an e-book and an extensive collection of worksheets that students use inside and outside of class. She stated, “I have been tweaking and adjusting each year.”

Bill, a seasoned instructor, began his change process by making lectures shorter and using student activities during class. Like Kennedy, Bill used PowerPoint presentations to accompany his lectures. Over time, as he’s witnessed students working collaboratively, he found himself “mesmerized by how little students got out of his lecture.” As he recounted, “I kept trying to do more and more active learning in class. Then, one day I decided to complete the active learning activity in class and not lecture anymore. I went cold turkey and it was definitely an improvement.” Although Bill purposely abandoned lecturing, he still frequently felt it necessary to include it. About three years later, a colleague introduced him to screencasting and immediately he caught on to it, and had the sense that, “my problem is solved.” He adopted screencasting as the method for delivering content to students and since then much of his focus has been on improving his screencasting techniques.

The adoption process of flipped learning for Taylor was the opposite of Bill's process, as she arrived at the adoption process totally from a technological perspective. After being a traditional classroom teacher for many years, she began teaching online with the Ohio Virtual Academy in addition to teaching classroom-based classes. As time went on, she learned of ProfCast, a software program that would allow her to record her lectures for her online students. Interested in this new technology, she began to create her own podcasts from her PowerPoint presentations. Working alone, she found the process to be simple, but time consuming. "It took longer than I'd anticipated" to create over 50 podcasts, a complete set for one of her classes. However, once the lectures were completed, "I could really start changing how the class worked. Now the students can watch the entire semester online and that allowed me to change up what I was doing in class." She started making some classes optional, providing online quizzes for students to assess their own learning and requiring students who attended class to bring questions about the lesson on which she would base the day's discussion. She now finds herself at another turning point in her career, to the extent that, "I don't think I'm going to miss the traditional class because I'm enjoying the discussions so much more."

One important characteristic of this continuous improvement process described by the mathematics teachers is the manner in which their progression emphasizes the lack of preparation for teaching (Ash, 2012; Berry, Byrd & Weider, 2013; Fullan, 1998; Wilson & Peterson, 2006). Mark stated that in his early years of teaching, "I had no understanding of the foundational concepts." Taylor said that "no one taught me to teach" and she had to learn about the pedagogy as well as the technology through her own efforts. Bill recalled his feelings after the visit from his mentor teacher: "I thought it was going to be easy, I was going to give a fun lecture and I found out I had no clue about teaching." Fortunately, for early adopters of flipped learning, like these mathematics teachers, discovering a lack of knowledge ignites in them the desire to learn and improve their skills. The set of characteristics they share, including a passion for teaching and the willingness to be a student, ensure that they will be motivated over time to become better teachers.

It is imperative to note the significant variations in paths that these mathematics teachers took. While their experiences echoed one another in many ways and their current practices have many similarities, they also just as often took divergent routes and came to their own unique solutions to the challenges they met within their distinct environments. In one manner, their stories read as if they were making it up as they went. The next question also demonstrates the patterns of similarities that connect the disparate journeys of the mathematics teachers.

What have been their experiences with increasing student engagement with flipped learning?

While the participants referenced a wide variety of influences during the course of their interviews, some commonalities can be seen. These instructors work in a variety of school settings and come from many different backgrounds and perspectives. As will be shown in this section, their experiences sometimes overlap and sometimes do not. Later sections will show that the amount and type of support they received greatly differs, as do the technology tools they have chosen or been provided, and as a result, the content conversion methods they use. They, of course, share commonalities necessary to be included in this study, but more importantly, they share the characteristics of early adopters, who are driven to constantly improve their teaching, enjoy experimenting as a method of improving their teaching practice, and are willing to implement new technologies and pedagogical methods. These characteristics shaped the discussion of student engagement as previously discussed in chapter 2.

Instead of expecting students to go at the teacher's pace, flipped learning, afforded students greater use of their time and perceived the class to be more engaging. Interestingly, the teachers used similar grading techniques. Student grades were based on their ability to demonstrate mastery. They did mastery checks based on 50% and unit tests as 50%. Students had to score at least a 70% on the unit test and at least 80% on each section mastery check to progress. Based upon this information, Table 4.1 shows how student achievement changed for each of the mathematics teacher's classes participating in this study. The results were acquired from each teacher through either teacher made assessments or from the previous years Ohio Graduation Test results of those students who had not passed the mathematics portion of the test.

Table 2 Change in student achievement

Teacher	Type of increase	Class
Melissa	7% reduction in failures compared to traditional instruction	Geometry
Taylor	11% increase on exams	Algebra 1
Bill	8% increase on final exam compared to traditional class	Algebra 1

Mark	Increased 5 points higher on semester exam than traditional class	Geometry
Kennedy	8.6% increase in number of students earning A/A-	Pre-Calculus
Tina	Increased 22% points on OGT Math test	Algebra 2

Using a standardized or teacher-made test to measure student achievement, like the Ohio Graduation Test, has some advantages and disadvantages. The advantages of using the Ohio Graduation Mathematics Test are, but not limited to, valid and reliable, useful when comparing students to other students, norms computed for purposes of comparison and interpretation; intended to be used for a long period of time; accompanied by instruction manuals; copyrighted (Newell, 2002). The disadvantages are, but not limited to, their ineffectiveness with students that have abilities, needs or problems that differ from those of the “normal” student population, the content on the test doesn’t necessarily match what has been taught in class, and the content and vernacular on a standardized test may not match the classroom content and vernacular in a particular school (i.e. urban, rural) (Shepard, 1989; Wiggings, 1989).

Teacher made assessments have advantages and disadvantages just as standardized tests. The advantages of teacher assessments include, but are not limited to, help test a student’s understanding of a limited body of knowledge and evaluation is based on the student’s performance and relates directly to what was taught. The disadvantages include, but are not limited to, unreliability, less valid than standardized tests; their effectiveness relies on the skill of the individual teacher who creates and grades the tests; single use; scoring may be subjective; and not copyrighted (Cassell, 2003; Foley, 1981).

In the flipped math classroom, teachers are able to more deeply engage with students by assigning lectures and other passive learning activities as homework and using in-class time for more active learning activities (Strayer, 2007). Flipping the mathematics classroom generates numerous benefits to both students and teacher. For example, studies show that flipped classrooms can significantly improve educational outcomes when compared to traditional classes (Marzano, Pickering & Pollock, 2001). Additionally, Deslauriers, Schelew & Wieman (2011) compared two large sections of an introductory undergraduate physics course: one section was taught as a traditional lecture by an experienced, highly rated instructor; the other was taught by an inexperienced instructor using flipped learning strategies. In the flipped class, student engagement nearly doubled, attendance increased by 20%, and average scores on assessments increased from 41% to 74%.

Grading assignments and lecturing are time consuming activities. The time savings from automating some of the repetitive lecture and grading practices affords teachers to spend more time on active learning activities, teaching problem solving, and providing one-on-one assistance to students who might be struggling with the concepts. As a result, flipped learning can improve teacher efficiency (Deslauriers, Schelew & Wieman, 2011; Lovett, Meyer, Thille, 2008).

Software platforms like Coursera, Moodle and Camtasia, allows the teacher to scatter in-video quizzes throughout their lectures, creating a more interactive, dynamic and personalized learning environment for students than traditional lectures offer. The teacher is also able to incorporate animations, simulations, and interviews with other professionals or countries that cannot be accomplished in a traditional lecture. Features of this type aid in maintaining student focus and engagement, while improving student performance and can significantly improve student outcomes (Cakir, 2008; Daggerr & McNulty, 2005; Karpicke & Blunt, 2011; Karpicke, Roediger, 2008).

When a mathematics teacher flips their class for the first time it can be daunting with several pitfalls. The study participants shared some of the pitfalls they experienced during their initial flipping of their mathematics classes. These pitfalls will be outlined below:

- I didn't sell the flipped classroom. My students resisted the implementation of the flipped learning strategy because I didn't frame it correctly.
- Initially I didn't change the way my classroom was set up, making flipping difficult.
- The videos didn't align with the in-class assignments
- I overloaded my students with out of class assignments
- Students wouldn't complete work assigned outside of class (i.e. watch video)
- I had a hard time differentiating the instruction during in-class activities

- I thought I still needed to be the “sage on the stage” not knowing that the “guide on the side” was more impactful

The mathematics teacher participants in the study have identified both the benefits and pitfalls of the flipped classroom. For these participants, flipped learning has been an important instructional strategy that they will continue to use. Finally, the percentages of the mathematics teacher responses are identified, below:

- Improved educational outcomes – 83%
- Efficiency of recorded lectures – 83%
- Ability to make lectures interactive – 100%
- More opportunities to collect and use data – 100%
- Ability to personalize learning – 67%
- Ability to facilitate mastery learning – 83%

Description of Research Sites

The study was conducted within rural, suburban, and urban school districts in Northwest Ohio and Southeast Michigan.

Rural. The lack of a clear, widely accepted definition of “rural” has impeded research in the field of rural education. It is necessary to define what areas are rural in order to determine the number of students residing in rural areas, and to describe the characteristics of educational programs for students with disabilities in rural areas. When defining the term rural, population density and remoteness are essential considerations because these factors strongly influence school organization, availability of resources, and economic and social conditions.

The U. S. Census Bureau defines a rural area as one that is not urban. “Urban” is defined as either an urbanized area or places with populations of 2,500 or more outside urbanized areas. An urbanized area includes places and their adjacent densely settled surrounding territory that together have a minimum population of 50,000 (U. S. Department of Commerce, 1992).

Suburban. Suburban schools exist in the outer suburbs of a city. It is usually characterized by its population of middle class white majority students whose parents have moved from inner city areas in generations past to find open spaces or to get away from high levels of crime. It typically reflects the affluence of its community.

Suburban schools were born out of the necessity to educate the children of parents who moved out from the inner urban areas of the city to the planned estates of the suburbs. The suburban school is slightly affluent and parents are more involved in the day to day running of the school.

Urban. Urban schools refer to schools in metropolitan communities that typically are diverse, characterized by large enrollments and complexity, many struggling with growth. Urban schools often serve students representing many ethnic minorities, multiple languages and have a greater concentration of the poor (Jabari & Tate, 2013).

Though there are many differences among children attending urban schools, one thing that often ties many of the students together in the urban context is their socioeconomic status. Many are children of poverty.

Individual interviews

There are certain limitations to using interviews as the primary data collection; however, these pitfalls can be avoided with proper preparation. For instance, overcoming the interviewer's perceptions and bias. In relation to finding out a mathematics teacher's experience of their approach to flipped learning in the context of the mathematics course, the only route into the mathematics teacher's own experience is that experience as expressed in words, therefore, the interview is the main source of data for this study. Semi-structured interviews were conducted in a conversation and discussion manner. The use of this approach provides a degree of structure to the interview while retaining flexibility to permit individuals to direct the interview. Ashworth & Lucas (2000) suggest that the researcher's task is to achieve "empathy and engagement" in an interview situation in order to give the participant the maximum opportunity to reflect on their own experience and to feel comfortable in talking about all of the aspects of the phenomenon of which they are aware. This, the researcher anticipated, would give each participant an opportunity to talk at length about flipped learning and provide me with a rich source of data. The interview was split into two parts with questions designed to be prompts so that participants could explore all areas of interest but also there were straightforward inquiry questions to obtain information such as previous levels of mathematics experience. The researcher decided to adopt the semi-structured type of interview for three main reasons. First, this approach provides not only extensive records of a participant's conceptions and experience, but also provides extensive data for evidence to support an argument. Secondly, it allows enough flexibility for the researcher and the participants to clarify meaning and explore completely the issues that arise during the interview process. Thirdly, using open-ended interviews depends very much on the ability of participants to recall and express extensively their beliefs and experiences.

On average the interview lasted about 45 minutes with the notable exception of the more experienced teachers who took up to 90 minutes to complete the interview. This was due to the fact that the more experienced teachers were more open to elaborating on their responses. The interviews were video recorded and then transcribed verbatim. Great care was taken in order that physical responses of the participants, such as facial expressions, body language, and laughter were recorded.

A criticism of interviews in which the researcher asks predetermined questions is that, by providing a structure for the interview, the researcher omits the opportunity to understand how the participants might choose to organize the topic being discussed. While this is a reasonable criticism, the semi-structured interview was chosen in this particular study because it allowed me to collect the data which could be compared across participants and provided a focus on the questions being investigated..

Saljo (1997) has questioned the validity of using interviews for the purpose of investigating teaching and learning, arguing that the context might be influencing the nature of the responses given. He also suggests that expressions in an interview indicate "the attempt to fulfill one's communicative obligations when being asked a question or a wish not to lose face when confronted with an abstract and maybe difficult question" (Saljo, 1997, p. 177). We learn about the socially appropriate ways of talking about our experience of a phenomenon and we frequently borrow accounts from stories which other people have told us. Therefore, it is assumed that it is difficult to disconnect what is said in an interview from its communicative function in that particular context. Marton & Booth (1997) also argues that the interviewee's statements are co-authored. Regardless of these criticisms, the interview for me remained the most appropriate method of data collection for this study. If the goal of the research is to find teacher's approaches to teaching, then it would seem appropriate to ask those teachers how they approached their teaching. The previous sentence should not be viewed as an over simplification of the research method as I did not simply ask teachers how they approach their teaching. Many of the criticisms mentioned above can be addressed by ensuring that the right questions are asked and that the interviewer is "qualified" to interview. In other words, the interviewer must have a clear understanding of the phenomenographic method and be able to put it into practice using an interview.

Overall the interviews provided data to answer the following research questions:

1. What are middle and high school mathematics teacher's experiences with the flipped learning model?
2. How do middle and high school mathematics teachers describe their experiences in increasing student engagement using the flipped learning model?
3. What contexts have influenced middle and high school mathematics teachers' experiences with flipped learning?

Data collection and analysis

As appropriate for a phenomenographic methodology, this study focused primarily on mathematics teacher interviews. There is no standardized procedure for phenomenographic data analysis and **TABLE 4.2** summarizes the steps adopted by three key phenomenographic researchers. Dahlgren & Fallsberg (1991) outline seven steps for phenomenographic analysis; Dean (2000) developed an eight-step sequence for phenomenographic analysis; and, Sandberg (1994) adapted five steps of phenomenological reduction.

Table 3 Analytical processes that provided insights for this study

Dahlgreen & Fallenberg (1991)	Dean (1994)	Sandberg (1997)
Familiarization: Read the transcript many times in detailed manner	Familiarization: Similar to Dahlgreen & Fallenberg's model	Orient the phenomenon as and how it appears
Condensation: Select the most significant statements from the transcripts to provide a short, representative agreement	Reflection: Densely code the statements of text as an initial analysis	Describe what constitutes the experiences
Comparison: Compare the excerpt for differences and similarities in order to source variations	Comparison: Compare the dense coding of potential categories	Horizontalization: Treat all aspects of the lived experience as equally important
Grouping: Sort excerpt similar meaning	Reflection: In-depth reading on coded statements and sort the statements with similar meaning	Search for structural features of the experience
Articulation: Make a preliminary attempt to describe the essence of the similarities	Condensation: Similar to terminology of Dahlgren & Fallsberg	Three steps to explicate the variation in the conception identified:

	Explication: Similar to what Dahlgren & Fallsberg termed "articulation"	1. Identify what the participants conceived as reality 2. Identify how the participants conceived that reality 3. Relate the participants' ways of conceiving to what they conceive as reality
	Labeling: Denote the various categories with a suitable linguistic expression	Categorization: Same as Dahlgren & Fallsberg's labeling step
	Contrasting: Compare the differences and similarities between the categories	Articulation: Same as Dahlgren & Fallsberg's model on "contrasting"

Additional sources of data provided by the study participants were incorporated both to inform the interview process and to contribute to the validation of data collected.

For example, Marton (1994) suggested that in order to understand the phenomenon as seen by the participants, bracketing should be explored. Specifically, bracketing allows the researcher to focus on similarities and differences between the ways in which the phenomenon appears to the participants. The process of working with each study participant is described below.

The researcher initiated contact with a prospective study participant by sending the participation request letter by email. The letter explained the focus, purpose and requirements for participating in the research study. The researcher attached the study participant questionnaire, in order to aid the potential study participants fit for the study. In addition, the informed consent form was attached. The study participants emailed agreement to contribute to the study constituted their consent to the conditions of the study. Interested candidates were able to request additional information prior to agreeing to participate in the study. The researcher addressed any and all questions and concerns potential study participants had.

Before scheduling each interview, the researcher reviewed the potential study participant's responses to the questionnaire in order to determine whether they were fit for the study. If a potential study participant was deemed not a fit, then a decline letter was sent to the participant thanking them for their time and effort. When the potential study participant was deemed a good fit, a participation confirmation letter was sent in order to notify the candidate and provide details to prepare for the interview. Each study participant was sent an email to confirm the interview time.

A semi-structured interview approach was used which allowed for flexibility in the interview process. Semi-structured interviews seek to both collect specific data and permit the exploration of topics with the study participants (Ashworth & Lucas, 2000). This interview format was selected to emphasize the collaborative nature of the study and benefit from each study participants role as expert on his or her own experience. To start, the study participant was asked to describe and discuss course materials used in their classes. During the process, the researcher offered short prompts to encourage further description as needed and took notes to keep track of the discussion and any additional questions that may have arisen. The researcher followed that discussion with a few open-ended questions. The focus of the interview was on the experience of the phenomenon and the content within which the experience took place.

As each interview drew to a close, the researcher asked whether the study participant wanted to discuss anything that had not yet been addressed. Follow-up procedures were reviewed, with time estimates provided when possible. On the day following the interview, an email was sent thanking the study participant for their participation and reviewing next steps. The study participant was advised that, as sometimes happens in a phenomenographic study, they might be contacted to respond to additional questions or for member checking purposes during the data analysis stage. During the later stages of the data analysis process, each study participant was emailed a report letter providing an update on the progress of the study.

Data analysis methods

In a phenomenographic study, data analysis begins with the careful review of the interview to understand study participants experiences. The researcher followed up each interview with a period of time for reflection, review and writing. A review of notes and other documents was completed immediately after each interview, detailing impressions from the interview and self-reflections of the process were included. All documents from each study participant were compiled to provide an easily accessible resource for the data analysis process. As I worked with the different study participants, it was imperative that I struck a balance between consistency in types of data obtained and accommodation of variety in the materials that were provided by the study participants.

Data analysis began at the beginning of the data collection process (Bruce, 1997). As each data source was created, it was examined and analyzed. The researcher reviewed each transcript several times, working to identify significant statements in an effort to uncover essential meaning (Patton, 2002). The statements were grouped in order to develop themes. Preliminary themes were based upon the research questions. However, the researcher also identified a number of emerging themes during the process of transcript review (Ellis, 2011). During the process of transcript review, the researcher worked to discover and describe both what each study participant experienced and the context in which they had that experience, including environmental and other influences. A more complete list of themes was assembled as each transcript was reviewed. This list was then used as the basis for later analysis of the data gathered. This resulted in the compilation and organization of data coding which began the data reporting process.

From the process of coding, tallying, and organizing the data the resulting outcome spaces were drawn: student-centered learning environment, individualized instruction, building 21st century skills, and improved effectiveness.

Interview analysis methods

All of the interviews were transcribed verbatim from the Skype recordings. Each teacher agreed to be recorded via the Skype interviews. The interviews being recorded allowed a degree of fullness to the transcriptions, which I believed would not have been possible with audio recordings alone. Any vocal tone shifts were recorded as well as hand and face gestures. Therefore, in analyzing the data, qualitatively distinct categories emerged that described variations in the mathematics teacher's perceptions, conceptions and approaches. I believed that a limited number of categories were possible for each research question and that these categories could be discovered by immersion in the data.

A core principle of phenomenographic research is the assumption that categories describing the variation in the ways of experiencing something are related to each other, typically by a hierarchical relationship, as previously discussed (Marton & Booth, 1997). However, Bowden (2005) and Ashworth & Lucas (2000), recommends that the analysis of this structural relationship between the categories be postponed until the overall meaning of the categories has been finalized. This is due to the fact that such structural links between categories requires the researcher to apply their own perspective and during the analysis the researchers own relationship to the phenomenon must be bracketed. Bracketing requires the researcher to deliberately put aside their belief about the phenomenon under investigation (Carpenter, 2007; Koch, 1995). In an effort to achieve bracketing, I delayed the literature review until after the participant interviews and classroom observations (Hamill & Sinclair, 2010). Therefore, all analysis was based completely on the interview transcripts (Bowden, 2005). He specifically stated, "if it is not in the transcript, then it is not evidence" (Bowden, 2005, p. 15).

Akerlind (2012) states that a strong emphasis on structure is necessary because one of the epistemological underpinnings of phenomenography is that logical relationships exist between different ways of experiencing the same thing. An outcome space is not simply a set of different meanings but should be a logical structure relating the set of meanings. Akerlind (2012) believes that this is imperative for phenomenographic analysis because it provides a way of looking at collective human experience of phenomena holistically, even though it maybe experienced by different people in different ways in various contexts.

Akerlind (2012) also believed that structure and meaning should be co-constituted from the data so that the resulting outcome space will have more practical application by making the variation in the experience meaningful. Distinguishing the critical aspects in the variation in the ways of experiencing a phenomena and, thereby, highlighting the structure of these critical aspects, allows for a better understanding of how individuals could be helped to move from a lower hierarchical category to a higher hierarchical category. Therefore, Akerlind (2012) recommends, in searching for dimensions of variation, that themes of expanding awareness be identified and discovered within the data.

In addition to the emphasis on meaning and structure in the outcome space, due to the assumption that when an individual is experiencing something the structure of their awareness can also be categorized by the two internally related dimensions, structural and referential aspects. During the clarification of the categories the “how” and the “what” teachers were saying are focused upon. The “how” in this case is “how is the explanation given?” and the “what” is “what is focused on?” (Trigwell, 2000).

Marton (1986) states that phenomenography provides categories that are qualitative, experiential, relational, and content-oriented. Svensson (1997, p. 171) further outlines the methodological assumptions involved in the analysis of phenomenographic research by arguing that the categories of description must be based on "exploration of delimitations and holistic meanings of objects as conceptualized" and also that categories are based on "differentiation, abstraction, reduction and comparison of meaning." The categories are not constituted from every detail in the interview transcripts, instead they represent a small number of holistic meanings with a focus on key aspects of the experience, which serve to link and separate the different categories of description. The process of analysis calls for the researcher to differentiate between critical variation and non-critical variation, with critical variation being described as "that which distinguishes one meaning or way of experiencing a phenomenon as qualitatively different from another" (Akerlind, 2012, p. 82), whereas non-critical variation is described as occurring within a way of experiencing and therefore, does not distinguish between ways of experiencing.

However, throughout the initial stage of examining the transcripts, I endeavored to keep a high degree of openness to any possible meanings. The transcript was considered as a whole. I also felt it was important to examine the transcripts as a group and not as individual samples as phenomenographic research aims to explore the range of meanings within a group and, categories, which constitute the outcome space represent the range of ways of experiencing a phenomenon. Akerlind (2012) states:

> "The aim is not to capture any particular individual's understanding, but to capture the range of understandings within a particular group. The interpretation is, thus, based on the interviews as a holistic group, not as a series of individual interviews. This means that the interpretation of an individual interview cannot be fully understood without a sense of the group of interviews as a whole."

During the first iteration analysis, I looked for both similarities and differences among transcripts, selecting significant statements and comparing these statements in order to find cases of variation and therefore, grouping them accordingly. Marton & Booth (1997) describe phenomenographic categories of description as being constituted by considering variations, discernment and simultaneity and this is what I endeavored to do at all times. I read the interview transcripts many times, each time with a particular aspect of the interview theme in focus and this was carried out using an essentially two-stage analysis. The first stage involved identifying and describing the overall meaning of approaches by highlighting and separating the section of the transcripts according to the themes which emerged, thus representing the "how" aspect. The second stage, which represented the "what" aspect, involved identifying what was focused upon within each overall meaning and searching each preliminary category and the transcripts as a whole for themes of expanding awareness.

Through this process initial hierarchical categories were constituted that described the variations in the ways that these mathematics teacher's approached flipped learning. Bowden (2005) strongly advocates a group process in phenomenographic analysis; however, Akerlind (2012) suggests that it is more than possible to carry out reliable and valid phenomenographic research as a sole researcher. I was the primary researcher in this study and was responsible for carrying out the analysis.

With the initial categories in mind, I re-examined the interview transcripts to determine whether the categories were sufficiently descriptive and indicative of the data. If there were cases that I felt could not be described by a category, the categories and the interview transcripts were re-examined and, in some cases, the descriptions were altered to ensure every aspect of the experience under investigation was described. At this stage, extracts from the transcripts were sought to support the descriptions of the categories, which I felt gave substance to the categories. This iterative data analysis procedure is consistent with a phenomenographic approach (Akerlind, 2012), as Marton (1986, p. 43) states "definition for categories are tested against the data, adjusted, retested, and adjusted again." Marton & Booth (1997, p. 134) state "the data shimmers in the intense light of our analysis."

Participant variation

Participants in this study were comprised of six mathematics teachers from Northwest Ohio and Southeast Michigan. Participants comprised of teachers with five to thirty five years of teaching experience. All six teachers had a bachelor's degree, two had master's degrees, one had a specialist degree and one was in his third semester of his doctoral program.

Participants within the study vary with regard to gender, age, amount and type of prior college experience, and level of comfort using technology. Participants included four females and two males. The sample included a variety of age ranges, one participant is in the 24-30 age range, three are in the 31-45 age range and two in the 46-59 age range. Participants have a wide range of experience with flipped learning, all have experience with traditional courses and most have prior experience with online courses. All participants indicate a moderate to high degree of comfort with the use of technology in a learning environment. Table 4.3 presents a summary of the variation in teacher characteristics by school.

Table 4 Teacher Characteristics

Name	Gender	Age	Years Flipping	Prior Experience	Preferred Modality	Years teaching	School Type
Kennedy	Female	31	3	Traditional Flipped Online	Flipped	5	Rural
Tina	Female	56	2	Traditional Flipped	Traditional	32	Urban
Bill	Male	57	5	Traditional Flipped Blended	Flipped	29	Suburban
Taylor	Female	31	1	Traditional Flipped Online	Flipped	6	Suburban
Melissa	Female	36	3	Traditional Flipped	Flipped	11	Urban
Mark	Male	33	2	Flipped Traditional Online	Flipped	8	Rural

Observation

In order to examine the actions of the mathematics teachers using flipped learning, 6 teachers were recorded teaching sessions over a nine-week period, which covered the mathematics curriculum of the third quarter using flipped learning. The recordings were then shared among the six mathematics teachers with the intention of each examining their instructional practice. Each mathematics teacher independently reviewed the tapes and listed each teacher's main actions of the way in which they interacted with their students. The mathematics teachers used their own value judgments to qualitatively distinguish between actions of a similar nature. For example, when a student asks a question this would be listed as an action, but the quality of the question can vary so it was important to be able to qualitatively distinguish between types of questions. It was, therefore, down to the researcher's experience to make value judgments on the quality of the questions. As the primary researcher, I ensured that I kept an overview of all the pairs to ensure consistency. A list of actions was prepared in relation to each teacher describing their behavior over three sessions and with these lists analysis could begin. The final analysis process of the observational findings examined mathematics teacher's actions for trends and created an overview of teacher's actions for each session.

During the classroom observations, I viewed students asking questions and assisting other students with the in-class assignments. The teacher participants in each flipped class was mobile as they assessed student progress. In one class, several students were not collaborating with others and at the end of class I asked the teacher about ways of dealing with that type of behavior.

Me: "How do you handle the less sociable student?"

Kennedy: "I typically try to go around the room to see if there was anything I could do to assist them and if not, I try to locate a student buddy for them?"

Me: “Does using the flipped learning model disregard introverts? Are students being forgotten for the sake of active engagement?

Kennedy: “I think it makes it harder for them because the focus is on active engagement and collaboration.” “Recently, I have been reading about reflective writing and the flipped classroom, which allows students to pause, think and make connections, and work through a problem before other students are given an opportunity to respond and this process seems to help all students.”

Me: “Is there anything else you’d like to add in regards to reflective writing and the flipped classroom?”

Kennedy: “Yes, I believe that by integrating opportunities for reflection in my flipped math class, learning opportunities will be created for both extroverted and introverted students. This is something that I will begin to incorporate into my classroom.”

This conversation prompted the researcher to investigate reflective writing in the flipped classroom. As the researcher investigated reflective writing and the flipped classroom, she found several researchers who experienced the same challenge of missing a whole segment of the student population and minimizing the importance of reflective engagement in favor of active engagement (Chesborough, 1999; Felder & Silverman, 1998; Strayer, 2012). However, these researchers explored the challenge from different perspectives, in an effort to learn more about how to increase student engagement and learning. For example, Strayer said that (2012) students in flipped classrooms need to have more space to reflect on their learning activities in order to make necessary connections to course content. Chesborough (1999) examined the question from the context of the Myers-Briggs Personality Inventory and Cain (2012) explained that extroverts thrive in active learning environments, like the flipped classroom; however, introverts may not. Cain continued by saying, “If we never give the students the opportunity to reflect or write individually in the flipped classroom, the we are doing a disservice to both introverts and extroverts. All students benefit from reflection because it allows students time to pause, think, make connections, and work through an idea before others have any input or criticism” (p. 74).

Through the aforementioned classroom observation and teacher interview, the researcher has realized the importance of providing students with moments of reflection. Moreover, the researcher believes that flipped learning in the classroom can create a learning environment that both challenges and supports all learners which will ultimately allow opportunities for all students to engage in both active and reflective experiences.

Three types of schools and six teachers were observed and interviewed. Each situation provides a glimpse of the teacher’s classroom experiences, the mathematical activities presented, and the roles of the teacher and students. The goal of Table 4.4 is to create a description of the interactions between the teacher and student and whether flipped learning could be identified. Specifically, the researcher addressed the following questions for each observation of each participant:

- What were the interactions between the teacher and students?
- How is flipped learning evident in the mathematics classroom?
- What role did technology play in the classroom?
- Were the mathematical activities engaging for the students?

The teacher observation is organized by type of school. It begins with a summation of the teacher/student interactions. Each observation is broken down into three sections:

flipped learning identified, the role technology played, and were students engaged. I coded each mathematical activity by observing a change in the mathematical focus. I used classroom observations, notes, and interviews for this analysis.

Table 5 Teacher Observations

Type of School	Teacher/student interactions	Flipped learning identified	Use of technology	What's going on in class?
Rural	Positive teacher interaction; students aware of classroom procedures and teacher expectations	Lesson type varies; Flipped learning is the expectation; some students have either watched the videos prior to class	Whiteboards; projector; teacher computer; some classroom computers; some graphing calculators	Students work collaboratively in small groups; students talking to peers; teacher walking around while students work on skills
Suburban	Teachers interact positively with students; students/teachers have a mutual respect for one	Teachers use videos for instruction of course content; teachers ask questions of students that	Interactive whiteboards are used for instruction; teacher computer; 1:1 iPads, all	Students work collaboratively in small groups; interaction with peers on task at-hand; student activities

	another; teachers have established boundaries with students	would require them to have watched the videos; teacher ask students rigorous and relevant questions about the videos	students have graphing calculators; clickers; Mimio	dependent upon the videos; teacher works 1 on 1 with less advanced students; students are asking higher-order questions
Urban	Positive teacher interaction; students respectful of each other; students aware of classroom expectations and procedures; teachers have a positive rapport with students; flipped is becoming a	Students are asked questions pertaining to the videos they were supposed to watch prior to class; most students appeared to have watched the videos; some students are moaning and groaning	Interactive whiteboards; clickers; graphing calculators; TI 30XII calculators; teacher computer; some classroom computers; students allowed to use	Students work collaboratively in small groups; students working individually; students interact with each other; teacher works with lower functioning students

	daily routine and expectation	about having to watch the videos	their own devices; one teacher used an IPEVO to make their whiteboard interactive	

The teacher participant's classrooms were well maintained and seamless in the transitions that took place. As the observer it was evident to me that the teachers had high expectations and was strictly no-nonsense when it came to managing their classrooms. Although I had not thought about this prior to my observations, I have come to the realization that when transitioning your classroom to non-traditional practices like flipped learning, one must consider student relationships. This is something that was evident in the daily routines of all of the mathematics teachers, as they interacted with their students.

A final observation was the level of expertise of flipped learning with each teacher. Most of the classrooms incorporated small group activities, but one classroom incorporated peer instruction flipped learning. This is a hybrid of the best elements of flipped learning and peer instruction (Faulkner, 2013). This allows students to discuss their answers with their neighbor and if they disagree on the answer, they try to convince each other of their answer. This provided evidence that peer instruction coupled with the relationships that develop in a flipped learning environment made the peer instruction flipped learning model extremely powerful.

Analysis of variation in patterns of experience

The first research question asks, “What are middle and high school mathematics teacher’s experiences with the flipped learning model?” In order to answer this question, the researcher used a phenomenographic approach to data analysis to identify and describe variation in the experiences of the phenomenon as indicated in transcripts of interviews from six mathematics teachers. The phenomenographic approach assumes that experience comprises both a structural aspect and referential aspect (Marton & Booth, 1997; Cope, 2004). “Structural aspect” refers to relationship among aspects of phenomenon, which allow it to be distinguished from a given situational context. “Referential aspect” relates to the meaning assigned to a phenomenon based on the recognized relationship among structural parts. Experiencing a phenomenon requires noting the structural relationship among aspects of the phenomenon as distinct from a situational context and assigning a meaning to it. Within this study, meaning refers to the cognitive and emotional significance ascribed to the phenomenon based on recognition of its structural aspect. Figure 2 presents a diagram of the anatomy of experience indicative of the relationship between structural and referential aspects.

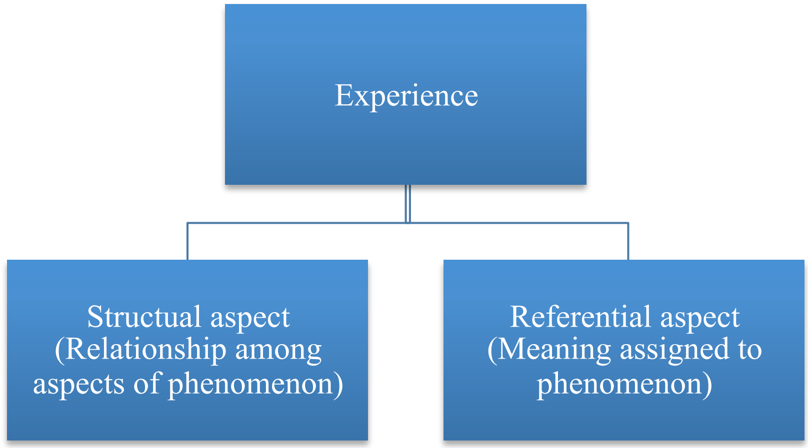


Figure 2 Anatomy of experience (Marton & Booth, 1997)

The anatomy of experience was used in this study to identify patterns representative of the qualitatively different ways mathematics teachers experience flipped learning (Marton & Booth, 1997). Identifying patterns in experience required grouping meanings of flipped learning (referential aspects) into patterns based on similarities and differences, identifying aspects of the phenomenon signified by teachers as critical to each pattern of meaning, and identifying a relationship among the aspects representative of the structural aspect of experience. Analysis indicates that aspects contributing to the experience of flipped learning can be grouped as components of context, process and teacher. The relationship among these components reveals the structural aspects critical to various meanings teachers assign flipped learning in the mathematics classroom. A pattern of meaning (referential aspect) and the corresponding relationship among components of context, process and teacher represent a pattern of experience of flipped learning.

The described analysis afforded recognition of three patterns of experience of flipped learning in the mathematics classroom: supplementary, interdependent and adaptable learning (McDonald, 2012). In supplementary learning, the mathematics teacher ascribe meaning to the experience of flipped learning based on the perceptions of two separate structural components, face-to-face and an online component, in which the online component served as a supplement to traditional face-to-face instruction (McDonald, 2012). The supplementary relationship allows greater flexibility in where and when students complete course materials. In interdependent learning, the mathematics teacher ascribe meaning to flipped learning based on the experience of a complementary relationship between the online and face-to-face components of flipped learning, which yields greater understanding of the mathematics content, peers and teacher (McDonald, 2012). Technology is considered a critical aspect of the flipped learning experience in this pattern promoting increased participation in the learning process (Moukali, 2012). In adaptable learning, meaning is ascribed to flipped learning based on the experience of the adaptability of the learning structure and learning process which results in a higher level of learning than could be achieved in a traditional face-to-face lecture. Mathematics teachers experience flipped learning as adaptable to the course content and the needs of the students, allowing them greater control over the process of learning.

The next section will explore the emergence of the patterns of experience noting the relationships among components of context, process and learner (structural aspects) corresponding to the different meanings (referential aspects) within each pattern. Recurring aspects contributing to the components of context, process and learners are identified in the discussion. In the analysis of the aspects of contributing to each component in a pattern of experience, aspects emphasized most are discussed first and those least emphasized are discussed last. Figure 3 represents the organization as related to the phenomenographic approach to the analysis of the experience.

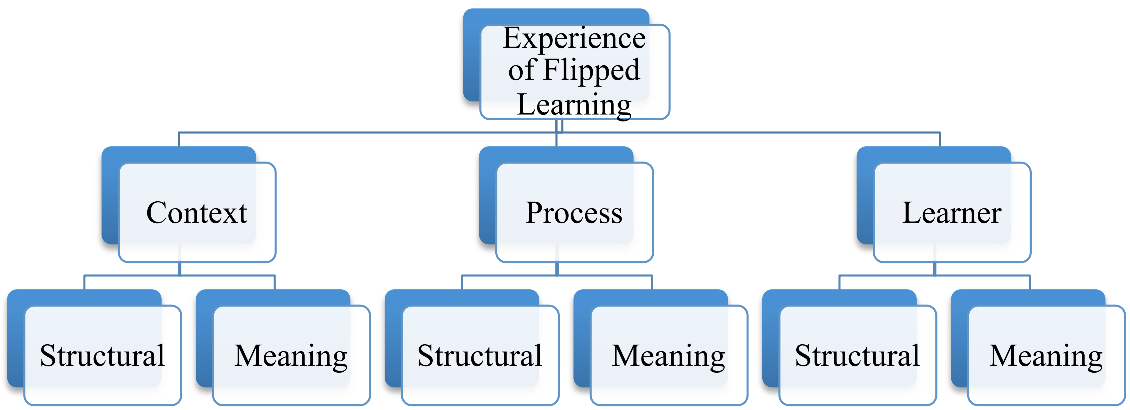


Figure 3 Organization related to the experience of flipped learning

Analysis reveals variation in the quality of aspects across patterns of experience and addresses variation in the relationships among context, process and learning components across patterns of experience. Considerations of the variations in aspect meanings and variation in component relationships across patterns of experience enable identification of four themes relating to the qualitative differences among patterns of experience.

Analysis of the quotations for the code meaning of flipped learning suggests patterns of experience based on the degree of relationship teachers perceive between the flipped and face-to-face portions of a flipped class. Moreover, within this group of statements related to the meaning of flipped learning, a pattern of meaning emerges indicating the experiences of the flipped portion of a course as a supplement to the face-to-face portion. The referential aspect of supplementary learning was assigned to this pattern of meaning.

External validity

To ensure the usefulness of research, a study should clearly demonstrate both internal and external validity, including reliability to its readers. The principle of internal validity seeks to establish the credibility of the research findings (Ary, Jacobs & Sorenson, 2013). More specifically, it asks how closely the observations and interpretations of the researcher match with reality. Triangulation was utilized both through multiple data collection methods and comparisons between study participants during the data analysis process. Member checks were also used to provide internal validity. Study participants were asked to review and provide feedback on their interview transcripts shortly after their production. Finally, the researcher practiced self-reflection at the beginning and throughout the study to observe and assess the perspectives she brought to the process.

External validity questions whether a study's findings would be valid if applied to additional instructor experiences outside the boundaries of the study (Hazelton, 2009). While qualitative studies do not seek to achieve generalizable results, this principle might be beneficial to qualitative research when seen in terms of the reader's ability to assess the value of the findings as applied to the experiences of others (Creswell, 2008). To ensure this form of external validity, this study offers a comprehensive description of study participants' experiences, allowing readers to make well-informed assessments of the usefulness of the findings to their own situation. The goal of the phenomenographic study is to provide a full understanding of the experiences of the phenomenon from which readers are able to derive meaning and benefit for their own work.

The reliability of a study, in qualitative research, is measured by the question "whether the results are consistent with the data collected" (Merriam, 2009, p. 221). Again, practices like triangulation, member checks and research reflexivity have been used.

The researcher's experience

The phenomenographic methodology requires the researcher to consider her connections with the phenomenon being studied, to maintain awareness of her responses and reactions throughout the study process, and to suspend judgment of the study participants' experiences and meanings. The researcher must constantly make the effort to keep personal perspectives from influencing the collection and analysis of data, as well as refrain from interpreting at each step of the process. The researcher is advised to practice self-reflection and include experiences with the study report as a means of providing additional internal validity and reliability. This section provides a review of the researcher's own experience of the study.

While this researcher has been a part-time college instructor for three years, teaching both classroom-based and hybrid courses, in addition to working in multiple middle and high school roles over a period of more than fifteen years, she has not yet designed or taught a completely flipped class. However, her choice to study this phenomenon reflects her strong interest in the concept and in the adoption of learning technologies in middle and high school teaching and learning in general. In addition, she has worked closely with a series of professors and presenters whose efforts to create engaging learning experiences for their students and colleagues often go unnoticed and are at times discouraging. She tends to lean toward a student-centered focus and the early adopter tendencies to quickly assess and implement new tools, technologies and strategies and is open to innovative ideas. In the following chapter, the reader will see she shares these characteristics with the study participants, which made her experience with the interviewing process stimulating and enjoyable. Her previous experience made her supportive of the nature of this study.

The researcher approached the study participants during the interview process as experts of flipped learning. This method required her to put aside her knowledge of flipped learning and afforded the study participants' the opportunity to explain flipped learning from their own perspective. The researcher brought with her active listening and questioning, which had been enhanced through her past roles as advisor and instructional coach. These skills, together with careful preparation and note taking allowed her to both guide and follow the study participants through their interviews. As the study progressed, the researcher worked tirelessly to achieve a balance between leading study participants through the steps of the study as originally designed and allowing study participants the flexibility to contribute their expertise as they chose.

Being a novice at conducting study interviews, the researcher learned several lessons from the process. For example, some study participants were extremely comfortable talking at length about their experiences while others needed more encouragement in the form of question prompts. A few uncomfortable instances occurred, but these were offset by many bonding moments, as the researcher made clear her authentic appeal in the details of study participants' experiences. Specifically, the video aspect of the interviews made it possible to observe reactions and build personal connections in a manner not possible with voice only interviews. Also, picking up on potentially interesting points and prompting for further discussions was made easier through visual observations, and demonstrated to study participants the researcher's interest in their work. The structure of the study proved beneficial in that it explored the unique narrative of each study participant while also collecting a manageable set of data for the analysis and reporting process.

The final phase of the study was challenging, yet enjoyable for the researcher. This phase consisted of organizing, analyzing and reporting the data. The comparatively petite study size allowed the researcher to keep each individual mathematics teacher in mind as she worked through several iterations of data review to assess and code the data set. The researcher practiced patience and used her ability to be open-minded and reflective, in order to guide her and enjoy the discovery of the results as they occurred. The researcher's strong interest in the phenomenon and personal connection to the success of the study provided much needed motivation while she worked to maintain an impartial viewpoint throughout the research process.

Findings

As a result of the data analysis, four qualitatively unique outcome spaces for experiencing flipped learning were arranged in terms of what was central during the mathematics teacher's experience: student-centered learning environment, individualized instruction, builds 21st century skills, and improved effectiveness. For each research question, an outcome space was developed that included the minimum number of categories, which explained all the variations in the data. Once I had defined the stable outcome spaces I then analyzed how the structure of the individual categories logically related to each other and how the outcome spaces related to each other. The entire process is described in more detail in Chapter 5 while outlining how each outcome space was constituted.

Outcome space

The manner in which an individual experiences a phenomenon is considered a conception (Marton, 2000). However, when the researcher develops categorizations of those conceptions they are referred to as categories of descriptions (Bowden, 2000). A single category of description consequently conveys one possible way in which participants might experience a phenomenon (Bowden, 2000; Marton, 2000). Although conceptions represent the experiences of the study participants', categories of description are the creation of the researcher (Marton, 2005).

The outcome space represents relationship between the different ways of experiencing the phenomenon of interest, specifically, flipped learning (Akerlind, 2012). Figure 4 provides a structural framework to show how the different categories of the learning experience are related. It provides a structure for understanding the phenomenon investigated. Overall, the outcome space of this study has four different categories, which describe mathematics teacher experiences with flipped learning: student-centered learning environments (category 1); individualized instruction (category 2); builds 21st century skills (category 3); and improves effectiveness (category 4).

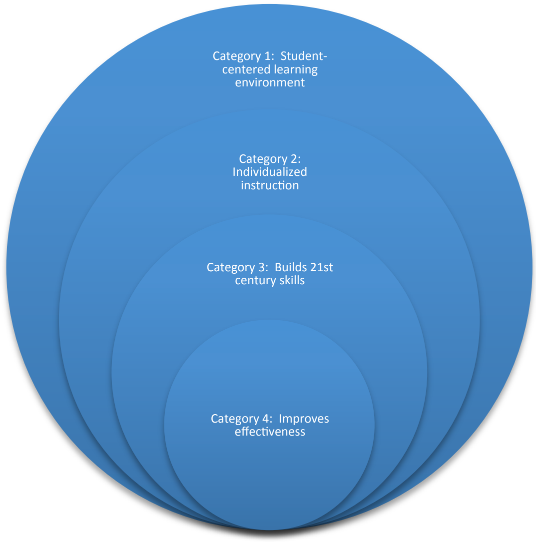


Figure 4: The outcome space for mathematics teachers' experience with flipped learning

These four form a hierarchy with category 1 being the broadest and most important result of experiencing flipped learning by the participants. Each of the categories was found to take a student-centered approach. In relation to the mathematics teachers' experiences with flipped learning category 4 was ranked lowest amongst the teachers in this study, however, every teacher in the study, experienced category 1. Each category was mentioned at teaching levels, with no clear preference for a specific category, based upon years of teaching.

Student-centered learning environment

One theme that emerged throughout the study was a change from teacher centered to student centered learning environments. Several participants identified this in relation to the change in their teaching practices through pre- and post- interviews and classroom observations. Kennedy commented "flipped learning allows for differentiated instruction because students are able to work at their own pace and I'm better able to group students with one another." Another participant, Steven, stated he was better able to engage students to construct viable arguments, critique their reasoning and students began taking ownership of their learning.

Moreover, teacher participants described a change in their role as the gatekeeper of knowledge to facilitator. Taylor described her experience like this:

> Flipping has allowed me to move from an instructor led classroom environment to a student centered learning environment. When I flipped my classroom, I had to shift the focus away from myself and toward the students and then I began using educational tools to enhance student learning. It has allowed me to focus on higher order thinking skills during class and lower level outcomes outside of class, to aid in student success. For example, students might simply watch a video before class and then come to class for more in-depth discussions about a particular topic that involves analyzing and synthesizing.

This change seems to be in alignment with the literature, as it affords teachers a better insight into students' learning styles and the concepts they are identifying as being difficult (Bergmann & Sams, 2012; Fulton, 2012). Given the nature of a student-centered classroom, teachers are better able to identify students struggling with understanding concepts and provide the support necessary for success (Bergmann & Sams, 2012).

Individualized instruction

Participants also reported a shift in focus to the student. They reported more time to work with individual students rather than the whole class. They reported flipped learning allowed students to work at their own pace, whether moving ahead, more peer interactions, and more attention to individual student needs. Kennedy shared her thoughts on small group instruction and individual student instruction differentiation. She said,

> Small group instruction lets me give guidance to those who are struggling. It allows me to identify where and how their mistakes are occurring. It provides me with opportunities to reassure students that they will get this and that they are growing in their skills. It enables me to correct misperceptions in a non-threatening and non-embarrassing way. It frees the kids up to ask more questions and ask for help, as needed it.

She went further on explaining how flipped learning allowed for more individual instruction. She stated that she was better able to differentiate instruction based on the needs of the student. Specifically, she references very high and low students and highlights independent learning:

> For instance, students are better able to work at their own pace which allows me the opportunity to work with individual students more than before. The autonomy I've gained to teach one-on-one, to clarify misconceptions, to enrich students who have mastered concepts, has been an awesome experience. I am able to correct a student during their practice time before delving too far into their work if they don't have the correct conceptual understanding. This is HUGE!

Many of the study participants reported a difference in their individual time with students and the time students were allowed to learn at their own pace. If students are given the appropriate time based upon skills and abilities, every student can master content (Hattie, 2009; Stacker & Horn, 2012). However, some participants were concerned with the need to guide students in self-regulation and owning their learning, so they began introducing students to the idea of flipped master and self-regulated learning. Specifically, Bill stated, "it was necessary to explain mastery and self-pace as well as the benefits of differentiation to students." Taylor went on to say:

Students were better able to work at their own pace and master the content at a pace that was beneficial for them. The problem, however, was that students tended to work much slower when they were not given a set amount of time to complete an assignment. She thought students working at their own pace was extremely beneficial for students who were able to work ahead of the other students because they were not being held back by slower students.

Another emerging theme from teacher participants was that students seemed to take control of their learning. This has also been a theme that emerged from the literature on flipped learning. For example, Lancaster (2013) states that the flipped learning model empowers students to take control of their own learning while Rutherford and Rutherford (2013) believe student engagement is due to the increased freedom and autonomy students gain. Furthermore, Berrett (2012) maintains that flipped learning affords students the opportunity to work at their own pace and engage their own learning strategies which results in a positive learning experience.

Building 21st century skills

Another theme that emerged is the building of 21st century skills. A change from traditional instruction strategies includes critical thinking, digital literacy and digital citizenship. Through flipped learning, students are encouraged to think critically by promoting their curiosity and broadening their knowledge. Critical thinking teaches the obstacles of dependence and the benefits of self-confidence. These are two invaluable lessons that prepare students for an increasingly unpredictable future.

Participants reported more time was available for projects, application problems, and more hands-on activities in mathematics class. They also reported that students work more collaboratively and are increasingly using technology for educational purposes. Bill noted:

> The biggest change I have noticed is that students are becoming self-directed learners and the autonomy they experience when and where they watch videos and how much they review the content gives them a desire to learn. Students feel more in control and gain skills that allow them to become more independent lifelong learners. It also allows them to manage their personal learning through reflection and decision making which are important skills for the 21st century.

Further, Melissa reported the use of and knowledge of technology are attributes students need:

> Digital literacy is a 21st century skill students cannot live without. Viewing lessons and collaborating daily through the use of technology, affords students the opportunity to broaden their horizons. Digital literacy and citizenship are embedded in their use of technology, as they (students) are encouraged to use devices for learning and development, instead of social accessories. Students are born with a digital footprint that makes being a digital citizen a focal point for education in the 21st century.

The flipped classroom is the ideal model to invest in 21st century skills, and provide students with a one-to-one learning experience, that works around them (Bergmann & Sams, 2013).

Increased engagement

Typically, math classes are stacked with diverse types of learners and when engaging them it is imperative to pay attention to students who are more reflective. Several study participants commented on their experience with student engagement using the flipped learning model:

> Tina stated: as a teacher, I love hearing my students arguing, debating, and discussing mathematics in my classroom. They are totally engaged in the learning process. When I was lecturing, my students sat passively in class and maybe were listening to me. When I flipped my class, my students were more engaged in the learning process than they were with lecture but nothing like how they are engaged during the peer instruction process.

> Bill stated: using the flipped learning model has increased interaction between the students and teacher while engaging students in the learning process. The focus is on the student's learning and they want to be challenged. They are more willing to show what they know instead of sitting in their seats looking confused. Not to mention, they want to engage in problem solving activities and discussions, which rarely happened before I flipped my classes.

These statements are in direct alignment with the literature on flipped learning. For example, Gerstein (2011) states flipped learning creates the face-to-face time to have a "much deeper interaction" between the teacher and student as they engage and interact on particular problems. Moreover, students are able to demonstrate what they have learned and apply the concepts in a way that makes sense to them, which aids in the creation of individualized learning (Bergmann & Sams, 2012; Gerstein, 2012; Leckhart & Cheshire, 2012).

The outcome of the mathematics teacher's varied experience with flipped learning has been addressed by analyzing the data and by analyzing their approaches to teaching. These parts are coupled with the meaning of flipped learning to construct the outcome space of the experience, flipped learning. By doing so, the final research question of the study is investigated.

This chapter describes the methodology behind this phenomenographic study and the steps taken to complete the study. Flipped learning and the qualifications for participation in the study are clearly defined. An explanation of the study process includes the methods for identifying, communicating with and interviewing study participants, the process and instruments of data collection, and lastly, data analysis and reporting. The challenges of working with the snowball sampling method highlight the need for contingency plans. Demographic and descriptive data help to introduce the study participants and, in combination with the data codes and their definitions provide a foundation for the study to follow. All study instruments and communication documents are included in the appendices. Finally, the researcher's experiences in conducting the study are shared. The next chapter provides the final report of the study, attempting for a fundamental understanding of the phenomenon and its meaning in the lives of those who experience it.

Summary

Using phenomenography to discover the differences of mathematics teachers experiences with flipped learning, given their educational backgrounds, is a reasonable way to approach the research questions. Although it is a newer methodology, education professionals have successfully used phenomenography in educational situations. Implications from their studies were used to guide my research. Supported in my experience as a mathematics teacher and a desire to know how mathematics teachers experience flipped learning, this research has merit and adds necessary information to the body of knowledge about mathematics education and teaching.

Chapter Five

Conclusion

A central idea in phenomenographic research is that there exist a fixed number of qualitatively different understandings of a particular phenomenon (Marton & Booth, 1997). The research focus of phenomenography is the intention to uncover variation in the experience. Therefore, sampling of participants for inclusion in a study aims at capturing the scope of variation in perspective in the targeted population. The phenomenographic approach was selected for this study on the basis of its potential to reveal variation in the ways mathematics teachers experience flipped learning (Marton & Bowden, 1998).

My overall research objective was to explore flipped learning through the experiences of rural, suburban and urban mathematics teachers in Northwest Ohio and southeast Michigan by addressing three research questions:

1. What are middle and high school mathematics teacher's experiences with the flipped learning model?
2. How do middle and high school mathematics teachers describe their experiences in increasing student engagement using the flipped learning model?
3. What contexts have influenced middle and high school mathematics teachers' experiences with flipped learning?

In doing so I adopted a phenomenographic approach due to the value it places on finding variations in experiences of the phenomenon under study (Marton & Booth, 1997). Evidence of how the methodology and results of the study addressed all of the research questions was presented in detail in chapter 4. In concluding the research, I will summarize the study and findings, compare definitions of flipped learning, identify various types of flipped learning, provide a critique of the study, identify limitation to the study, explain emerging themes, and make recommendations for future research.

Summary of the Study

Six mathematics teachers volunteered to participate in the study, which investigated their experience of flipped learning in their class. Taking the phenomenographic perspective of learning into account and the conception of flipped learning, I used classroom observations and an interview protocol to collect data on mathematics teachers' definitions of flipped learning, their use of flipped learning strategies in the mathematics classroom and their strategies for instruction (Marton & Booth, 1997). By analyzing each participant's responses through an iterative process, I identified categories of description for experiences, meaning of instruction, skills building, and improved effectiveness.

I further analyzed descriptions within the four outcome spaces to establish links between strategies for instruction and conceptions of learning as well as connections between conceptions of learning and conceptions of mathematics. The links between variations and levels of integration of flipped learning in rural, urban and suburban mathematics classrooms in Northwest Ohio and southeast Michigan stems directly from the three guiding research questions and from the experiences of the six mathematics teacher participants.

Summary of Findings and Connections to Literature

This study investigated mathematics teachers experiences using flipped learning and presented four outcome spaces: student-centered experiences (category 1), individualized instruction (category 2), builds 21st century skills (category 3), and improved effectiveness (category 4). These four categories form a hierarchy.

The findings regarding the link within approaches to teaching mathematics are consistent with teaching and learning from the phenomenographic perspective. As I discussed in chapter 2, the theoretical framework behind the study defines a flipped learning mathematics classroom where activities create knowledge, transfer knowledge, and apply knowledge (Horton, 2012). The success of using flipped learning in the mathematics classroom is dependent upon the synergy between the teacher and students. It also involves sustained engagement and involvement before, during and after live instruction. Specifically, flipped learning empowers students with being responsible for attaining the content prior to coming to class, at which time the teacher facilitates the application of concepts (Fulton, 2012; Strayer, 2007).

The constructivist learning theory is a philosophy that learning is the formation of abstract concepts in the mind to represent reality. Constructivism contends that the use of interactive activities can engage and motivate learning more effectively (Vygotsky, 1978). Piaget (1968) posited that individuals learn better when they discover independently and control the pace of their learning. Flipped learning supports the theory of constructivism by increasing class time for inquiry-based learning (Brandt, 1997). As a result, flipped learning and the constructivist theory allow students to engage interactively, creatively, and collaboratively during the construction of knowledge (Heinz, 2005).

Vygotsky's zone of proximal development theory also fits flipped learning (Ngeow & Yoon, 2001). Vygotsky held that in the zone of proximal development model the student generates knowledge and meaning from interaction between their experiences and their ideas (Vygotsky, 1978). Moreover, the concept of the zone of proximal development defines the potentiality of learning and development in terms of the student's joint activity with others. Furthermore, he viewed scaffolding by soliciting student's interests as it related to a task or the simplification of tasks to make learning more achievable for the student (Kuh, 2001; McMahon, 2006). This corresponds with the philosophy of flipped learning where the teacher can use class time to collaborate and individualize instruction.

Due to the relatively recent popularity of flipped learning, research has not been done to determine the differential effect of mathematics teacher's experiences in flipped learning in rural, urban or suburban school districts in Northwest Ohio and southeast Michigan. Vygotsky's zone of proximal development suggest that the teacher can provide scaffolding affording students the opportunity to perform above their current level of development (Vygotsky, 1978). Studies examining the effectiveness of flipped learning currently consist of either case studies or comparison studies (Bergrstom, 2009; Fulton, 2012; Lage, Treglia, Platt, 2000; Tucker, 2012). Case studies are informative, but not generalizable and researchers of comparative studies are finding positive trends in a flipped learning environment compared to a traditional environment (Bergstrom, 2011; Tucker, 2012).

Common characteristics are shared with all flipped mathematics classrooms although no two flipped mathematics classrooms are the same (Bergman & Sams, 2012;

Bhatia, 2014). Hamden, McKnight, McKnight, & Arfstrom (2013) suggest that flipped learning allows the teacher more time for the student to collaborate with peers, engage more deeply with content, and receive immediate feedback from the teacher. The most important result of the flipped mathematics classroom, according to this study's participants, is having one-on-one contact with every student during each class period. Based on the experiences of the six participants, the flipped mathematics classroom has established an outcome space that incorporates four categories: an increase in student-centered classes, differentiated instruction, building of 21st century skills and improved effectiveness.

Participants expressed how reflecting upon their experiences and their use of flipped learning are a valuable addition the mathematics classroom as evidenced in the research. The mathematics teachers in this study concluded that implementation of flipped learning in their classes not only improved student engagement during class, but it provided more structure and opportunities for learning outside of class. The study participants also described their experience with flipped learning as student-centered experiences (category 1), individualized instruction (category 2), builds 21st century skills (category 3), and improved effectiveness (category 4). The results of this study will add to the theoretical understanding of teacher knowledge by mapping teacher experience of flipped learning. One use of this understanding may be to inform instruction in the mathematics classroom.

The mathematics teacher's in the study did not use educational terminology such as guided learning to describe their experience of flipped learning (Chaplin, 2009**),** neither did they discuss levels of flipped learning (FLN, 2014**).** Even though all teachers welcomed student questions, only two teachers talked about using student questions to guide their teaching experience (Withee & Lindell, 2005**).**

Flipped learning definitions compared

This section will now consider definitions of flipped learning. Flipped learning was influenced and universalized by recent approaches such as inverted classroom or reversed teaching (Lage, Platt, & Treglia, 2000), as a means of maximizing student engagement in class by using a variety of delivery formats to assist in the development of student self-regulated learning outside of the normal classroom.

Flipped learning has emerged as both a disruption and an opportunity for the education community. The concept reverses traditional thinking regarding the instructional process and appeals for the use of innovative strategies to deliver the course content (Berrett, 2012). Flipping the classroom can help promote student engagement and require more of both the teacher and student (Zhang, Wang, & Zhang, 2012).

Advances in technology allow the delivery of content in ways previously impossible or that were too costly. Technologies that use online video and audio have made it more feasible to deliver asynchronous instruction to students in the increasing number of flipped classrooms (Talbert, 2014c). The flipped classroom is not defined by technology. The main idea is to shift the attainment of content before class in the form of instructional videos, recorded lectures, webinars, and other remotely accessed instructional items. Then, the teacher spends in class time applying the material through complex problem solving, deeper conceptual exposure and peer interaction (Strayer, 2012; Tucker, 2012). Moreover, Bergmann & Sams (2012) identify several benefits of the flipped classroom when materials are made available in a blended, online and in class, structure. Those benefits include increase in student-centered classes, differentiated instruction, building 21st century skills, and improved effectiveness.

The Flipped Learning Network (2014) defined flipped learning as moving direct instruction "from the group learning space to the individual learning space" (p. 1) causing the "resulting group space to be transformed" (p. 1). This affords students the opportunity to develop critical knowledge and understanding before class and to garner a deeper understanding of the subject during class (New Media Consortium, 2014). Sarawagi (2013) suggests that flipped learning is defined by the facilitation of low level learning outside of class and high level learning within class. During class the teacher "guides students as they apply concepts and engage creatively in the subject matter" (FLN, 2014, p. 1). Hamdan, McKnight, McKnight, & Arfstrom (2013) defines flipped learning as the process by which the teacher shifts "direct learning out of the large group learning space and move it into the individual learning space with the help of one of several technologies" (p. 4).

In order to further distinguish and define terminologies, flipped classroom and flipped learning are not interchangeable and one may not always lead to the other (FLN, 2014; Talbert, 2014a). According to Flipped Learning Network (2014), in order for flipped learning to effectively occur "four pillars" (p.1) and eleven indicators must be applied to the practice. Those four pillars are:

1. Flexible environments – expect class time will be "somewhat chaotic and noisy" and timelines and expectations for learning assessments will have to be flexible, too.

2. Learning culture – classroom becomes student-centered; “students move from being the product of teaching to the center of learning.”
3. Intentional content – teachers evaluate what they need to teach directly in order for class time to be used for other methods of teaching; “active learning strategies, peer instruction, problem-based learning, or mastery methods, depending on the grade level and subject matter.”
4. Professional educator – constantly observe students, providing feedback, and assessing student work; reflective in their practice, connect with others to improve their instruction, accept constructive criticism, and tolerate controlled chaos in their class

FLN (2014) created eleven indicators that educators should use when reflecting on their own classroom practices related to flipped learning. The eleven indicators are listed in Table 5.1. Montera-Gutierrez’s (2006) findings are consistent with the Flipped Learning Networks four pillars, in that educators have found that students prefer flexibility, setting their own pace and choosing when and where to learn (Richards & Ridley, 1997; Tallent-Runnels, et. al., 2006).

Table 6 Flipped Learning Network Checklist of Indicators

Flexible environment	**Culture shift**	**Intentional content**	**Professional educator**
I establish spaces and time frames that permit students to interact and reflect	I give students opportunities to engage in meaningful	I prioritize concepts used in direct instruction for learners to access on	I make myself available to all students for individual, small

on their learning as needed	activities without the teacher being central	their own	group and class feedback in real time as needed
I continually observe and monitor students to make adjustments as appropriate	I scaffold these activities and make them accessible to all students through differentiation and feedback	I create and/or curate relevant content (typically videos) for my students	I conduct ongoing formative assessments during class time through observation and by recording data to inform future instruction
I provide students with different ways to learn content and demonstrate mastery		I differentiate to make content accessible and relevant to all students	I collaborate and reflect with other educators and take responsibility for transforming my practice

Finally, by defining and distinguishing the terms *flipped classroom* and *flipped learning* and explaining the four pillars of good practice, the Flipped Learning Network has provided greater clarification of flipped learning and how to reflect upon its practice.

Various models of flipped learning

It is beneficial to understand that while reported as examples of flipped learning research, published and conducted studies before the Flipped Learning Network (2014) publication might essentially document a varied range of student-centered approaches and might suffer from insignificance considering the paradigms of interest. Furthermore, evident in previous research on best practices of teaching and learning, "any student-centered educator would provide activities in the classroom that are action based, authentic, connected, collaborative, innovative, high-level, engaging, experience-based, project-based, inquiry-based, and self- actualizing" (Arfstrom, Hamdan, McKnight, & McKnight, 2013, p. 17). For instance, Arfstrom et. al. (2013) include peer-instruction, active learning, priming, and pre-post class modeling that are designed to reduce cognitive load as central aspects of flipped learning.

One model of flipped learning is the "mastery." Bloom (1971) created the term mastery learning. In mastery learning, "the students are helped to master each learning unit before proceeding to a more advance learning task (Bloom, 1985). Specifically, this form of flipped learning uses video lessons as a support mechanism and students have to demonstrate mastery of a skill or standard before moving on to the next lesson. Students view videos and solve problems based on their readiness to take on more challenging problems. The challenge of mastery learning for the mathematics teacher is to manage the class when students are working on various lessons simultaneously (Farris-Berg, Dirkswager, & Junger, 2013).

During my observation of Bill, he used flipped mastery affording him the opportunity and freedom to be flexible. Flipped mastery, according to Bill, was a major adjustment, but he stated, "Although initially it was a lot of work. I am glad that my students are able to experience success in their math skill all while being challenged beyond their wildest dreams."   He further stated that he liked using flipped mastery, albeit for selfish reasons, because it reduced daily lesson planning and grading papers. He said, "Replacing lectures with group and individual activities increases student engagement." Heo & Choi (2014) suggests flipped mastery allows most students to complete a year's work in less time and slower learners get more personalized attention. The use of flipped mastery to reach various types of learners may be due to classroom environment and relationships and according to Bill, "I was unable to do this is in the traditional classroom."

Kennedy used a hybrid of the best elements of flipped learning and peer instruction referred to as peer instruction flipped learning. This model was created after a traditional classroom lecture yielded week conceptual understanding of the subject matter (Mazur, 1997). He wanted to increase student-to-student interactions using peer instruction (Crouch & Mazur, 2001). Moreover, in this strategy, the instructor poses conceptual questions during the lecture and students, in groups of no more than four, must reflect, respond, discuss, and attempt to reach a consensus on the answers (Mazur, 1997). This method shifts the teacher from delivering content to facilitator of discussion or "guide on the side" (King, 1993, p. 30).

In peer instruction flipped learning, students are still exposed to the materials before class, when they come to class they have no less than two questions on the board related to the video lesson they jut watched. She stated students had to answer the questions without any assistance from anyone, but they were allowed to use their notes. Once they have answered the question, then they turn to their neighbor to discuss their answer, during this process they may discuss, argue, or debate mathematics in class and get at their thinking and reasons for their answer. In a typical peer instruction flipped learning class, multiple discussions go on at the same time causing students to be emotionally engaged in the learning process since they have to defend their answer or wonder if they are correct.

Peer instruction flipped learning empowers students (McLauglin, et. al., 2012). This form of flipped learning cultivates critical thinking by shifting the use of class time. Kennedy stated, "My use of peer instruction flipped learning has led to an increase in student achievement and higher order thinking during class. This has provided students with greater value in their decision making skills and abilities." Murphee (2014) found similar qualitative results on decision-making in his study of 106 students in an undergraduate course. His results showed that greater emphasis was placed on the writing component of the class giving students real feedback on their writing and research. However, Kennedy attributed the increase in learning in her mathematics class is due to having students do mathematics in class as a result of using flipped learning and peer instruction discussions in class and the relationships that have formed as a result of flipped learning.

Flipped learning is a complex process when compared to traditional instruction. In the past, students and teachers were confined to a sequential approach to learning mathematics. Flipped learning offers a different approach in the mathematics classroom, with more opportunities to develop habits of mind and mathematical discourse chunked into a series of screencasts, webinars or videos (Heid, 2003). For example, prior to the widespread availability of handheld and mobile devices, mathematics students' were more than likely complaining, "I don't have Internet!" With advances in mobile devices and wireless technologies, students can watch a screencast, webinar or video anywhere and anytime.

Limitations to the study

The study presented contributes to the broad framework of mathematics teacher experiences with flipped learning, with a focus on rural, suburban and urban school districts. The mathematics teachers' descriptions are snapshots of their experience. The conceptions that emerged are limited to the duration of the study, under the assumption that mathematics teachers' perception of their experience will change as they garner more experiences with flipped learning in their mathematics classroom. The framework is generalizable to the extent that similar research on a larger sample of participants may yield similar conceptions as well as expand the outcome space to bring into focus a complete description of flipped learning.

Although the purpose of the presented framework is to explain relationships among meaning, flipped learning and instructional strategies, an indicator of the scope of each conception is unclear. For example, if a teacher's conception of flipped learning is categorized student engagement, then a variety of instructional strategies preferential to the teacher can be assumed to meet this end, but I did not investigate the sum and complexity of the instructional strategies in the study. Furthermore, if the mathematics class is structured based on the elements of flipped learning (FLN, 2014), then the same student should at least reach a level in which mathematics is seen as mathematical procedures and conceptual explanations (Cobb, 1988). The range of understanding in procedures and conceptual explanations was not investigated in the study because an assessment instrument on mathematical thinking and a learning styles inventory was not administered to study participants. In future research, I anticipate deepening my understanding of flipped learning instructional strategies and their association with the range of capabilities and the range of assigned meanings, in order to identify the origins of mathematical thinking and reasoning can be made.

Emerging Themes

This study investigated mathematics teachers experiences using flipped learning and presented four outcome spaces (themes): student-centered experiences (category 1), individualized instruction (category 2), builds 21st century skills (category 3), and improved effectiveness (category 4). These four categories form the following hierarchy. Each category was mentioned at teaching levels, with no clear preference for a specific category, based upon years of teaching.

Student-centered learning environment

One theme that emerged throughout the study was a change from teacher centered to student centered learning environments. Several participants identified this in relation to the change in their teaching practices through pre- and post- interviews and classroom observations. Kennedy commented “flipped learning allows for differentiated instruction because students are able to work at their own pace and I’m better able to group students with one another.” Another participant, Mark, stated he was better able to engage students to construct viable arguments, critique their reasoning and students began taking ownership of their learning.

Individualized instruction

Participants reported more time to work with individual students rather than the whole class. They reported flipped learning allowed students to work at their own pace, whether moving ahead, more peer interactions, and more attention to individual student needs. Additionally, study participants felt students seemed to take control of their learning. This has also been a theme that emerged from the literature on flipped learning. Berrett (2012) maintains that flipped learning affords students the opportunity to work at their own pace and engage their own learning strategies which results in a positive learning experience.

Many of the study participants reported a difference in their individual time with students and the time students were allowed to learn at their own pace. If students are given the appropriate time based upon skills and abilities, every student can master content (Hattie, 2009; Stacker & Horn, 2012). However, some participants were concerned with the need to guide students in self-regulation and owning their learning, so they began introducing students to the idea of flipped master and self-regulated learning.

Building 21st century skills

Another theme that emerged is the building of 21st century skills. A change from traditional instruction strategies includes critical thinking, digital literacy and digital citizenship. Through flipped learning, students are encouraged to think critically by promoting their curiosity and broadening their knowledge. Critical thinking teaches the obstacles of dependence and the benefits of self-confidence. These are two invaluable lessons that prepare students for an increasingly unpredictable future.

Participants reported more time was available for projects, application problems, and more hands-on activities in mathematics class. They also reported that students work more collaboratively and are increasingly using technology for educational purposes.

Increased engagement

Typically, math classes are stacked with diverse types of learners and when engaging them it is imperative to pay attention to students who are more reflective. For example, Gerstein (2011) states flipped learning creates the face-to-face time to have a "much deeper interaction" between the teacher and student as they engage and interact on particular problems. Moreover, students are able to demonstrate what they have learned and apply the concepts in a way that makes sense to them, which aids in the creation of individualized learning (Bergmann & Sams, 2012; Gerstein, 2012; Leckhart & Cheshire, 2012).

Implications for Educational Research

The significant contribution of this research is the prospect it provides to reflect on the factors affecting ways mathematics teachers experience flipped learning. Teaching mathematical thinking is important for solving mathematical problems (Garner & Garner, 2001; Heid, 2003; NMAP, 2008), but researchers emphasize the importance of providing opportunities for student's to engage in investigations that encourage them to engage in mathematical thinking (Pellegrino & Hilton, 2012). Further research should be considered in exploring how students construct mathematical knowledge within a flipped learning environment as compared to a traditional mathematics class.

Recommendations

This study focused on mathematics teacher experiences of flipped learning. The summary of the research concludes that the mathematics teachers in this study feel that their students have benefited from flipped learning and they will continue to use it in their classrooms. The study had a limited number of participants due in part to the type of study conducted, phenomenographic approach. Six participants cannot be taken to be representative of all mathematics teachers who use flipped learning, but their participation in my study can be used to demonstrate possible themes and variations in the ways flipped learning is a part of the mathematics classroom. A study with a larger sample size across different grades and subjects would be beneficial in order to see if the results found in this study prove similar.

The findings of this study suggest that regardless of the type of school, mathematics teachers teach flipped learning differently. This differentiation related to mathematics teacher experience needs to be addressed. Clearly, more research has to be conducted regarding teacher experiences with flipped learning. The following questions emerged from this study to impact how mathematics teachers can implement flipped learning in their classroom, given the barriers of differentiated educational settings.

1. How can school districts address the cost of technology without raising taxes?
2. What are specific features, if any, of a flipped classroom that promotes mathematics discourse and conceptual understanding?
3. Is it possible to add a component of engagement to the flipped mathematics video? Can this component aid in student mathematical reflection and improve student achievement?
4. How efficiently do mathematics teachers use flipped learning to improve

conceptual mathematics knowledge?

5. Do mathematics teachers in the same district experience flipped learning similarly?
6. How does the mathematics teacher incorporate flipped learning with the math common core standards?

Allowing mathematics teachers experience of the qualitatively different ways of implementing flipped learning uncovered, in this study, is expected to aid mathematics teachers to move towards a more student-centered learning environment. Extending beyond this to challenge mathematics teacher's epistemological beliefs regarding the source of knowledge may also aid them in developing more informed philosophies of flipped learning. The development of mathematical competencies in students will afford students opportunities beyond the mathematics classroom.

Final thoughts

Although this study investigated mathematics teacher experiences using flipped learning and presented four categories of emerging themes: student-centered experiences (category 1), individualized instruction (category 2), builds 21st century skills (category 3), and improved effectiveness (category 4), there is still little empirical evidence of these taken together within the model of flipped learning to support student achievement and engagement. However, as I have reviewed the literature of flipped learning, I believe the incorporation of flipped learning into the mathematics classroom is critical in order to reach today's student and there is significance to flipped learning in the mathematics classroom that is worthy of further inquiry. Most significant is the research from teacher practitioners (Bergman & Sams, 2012; Hamdan, et al, 2013; Tucker, 2012). I believe flipped learning allows teachers to improve communication and connection with students who possess a broad range of abilities. I further believe flipped learning has caught the attention of many educators, administrators and lawmakers primarily because of what teachers are saying and are implementing flipped learning on their own. As a mathematics teacher, I believe the use of flipped learning in the mathematics classroom can have a positive impact on students' learning, with significant gains in mathematical achievement and conceptual understanding.

The results of this phenomenographic study suggest that the mathematics teacher participants who used various types of flipped learning in their classroom had an increase in student achievement and engagement. There is also evidence that mathematics teachers who use flipped learning as an integral part of their instruction tend to foster more of a constructivist-learning environment. Flipped learning moves from the group learning space to the individual learning space resulting in a dynamic, interactive learning environment where the teacher is no longer the "sage on the stage" but the "guide on the side." For example, Tina moved around the room talking with different groups, making suggestions as to how to proceed, or pointing out possible errors in a particular line of reasoning the students are following

The research on flipped learning as experienced by the mathematics teacher is virtually non-existent; however, studies have shown that flipped learning has improved student performance and perceptions (Love, Hodge, Grandgenett, & Swift, 2013; Moravec, Williams, Aguilar-Roca, & O'Dowd, 2010). Each of theses studies and this phenomenographic study suggests the most important aspect of flipped learning is the change in face-to-face class time not the videos. These results help inform the theoretical understanding of mathematics teacher understandings of flipped learning. Knowing what teachers actually experience through flipped learning, as opposed to theoretical understanding, is a worthwhile contribution to the literature. This knowledge provides a valuable contribution to curriculum development and the practicing middle and high school mathematics teachers to more completely understand and implement best practices in their daily instruction.

With advances in technology, it is becoming increasingly easier for teachers to offer dynamic multi-media educational resources to support both content and assessment between mathematics teacher and students (Sullivan, McDonough & Harrison, 2004; Talbert, 2014d, USDOE, 2010). I believe true instructional reform in the mathematics classroom that increases student content knowledge while building 21st century skills is possible through the use of flipped learning. Educators and school administrators must understand the reality and prevalence of technology in the lives of students, "American schools aren't exactly frozen in time, but considering the pace of change in other areas of life, our public schools tend to feel like throwbacks. A yawning chasm separates the world inside the schoolhouse from the world outside" (Wallis & Steptoe, 2006, p. 2). Studying the flipped classroom is a rich area of research. In particular, investigating many facets of the mathematics flipped classroom at the primary and secondary levels is an area of research that has not been explored extensively. Implications for further research lie in creating new models for flipped learning instruction in mathematics that will produce more effective outcomes in teaching and aiding students in the optimization of their learning. No longer can educators ignore the fact that we must continue in our quest for tools to aid in shifting from traditional instructional practices towards one that reaches every student in every class daily (Bergman & Sams, 2012), particularly if we are going to meet the pressures of new standards, assessments, and improve teaching and learning through 21st century instructional models.

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Appendix A

Interview Questions

1. What is your definition of a student-centered learning environment?
2. How would you describe flipped classroom and flipped learning?
3. Have you received any training in using the flipped learning model?
4. What experiences have you had with flipped learning before this school year, if any?
5. Have you used flipped learning in your mathematics classroom? Please describe this experience.
6. If you used flipped learning, what were the effects on you as a teacher, if any?
7. If you have used flipped learning, will you continue to use it in the future? If you have not used flipped learning, will you use it in the future?
8. How long have you been teaching?
9. What, if anything, would you like to add?

Appendix B

Documented Problem Solutions

Adapted from Angelo, T.A. & Cross, K.P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers.* 2nd. ed. San Francisco: Jossey-Bass Publishers.

Overview: To become truly proficient problem solvers, students need to learn to do more than just get correct answers to textbook problems. At some point, they need to become aware of how they solved those problems and how they can adapt their problem-solving routines to deal with messy, real-world problems. The Documented Problem Solutions technique prompts students to keep track of the steps they take in solving a problem – to "show and tell" how they worked it out.

Procedure:

1. Select one, two, or three representative problems from among the problems students have studied during the previous few weeks. If you decide to assign three problems, for example, try to select at least one that all students can solve, another that most of the class can solve, and a third that will challenge most of your students.
2. Solve the problems yourself, and write down all of the steps you take in solving them. Note how long it takes you and how many steps each problem solution required.
3. If you find any of the problems too time-consuming or too complicated, replace or revise them.
4. Once you have good problems you can solve and document in less than thirty minutes, write them up for the students. Assume that it will take students at least twice as long as it took you to document the solutions. Make your directions very explicit.
5. Hand out and explain the assessment problem(s), making clear to the students that it is not a test or quiz. It is more important for students to explain how they try to solve the problems than to get the right answers. Having well-documented steps is even more important if they fail to get a correct answer, since they can then diagnose where and how they went wrong.

Variations

1. Use this device as a diagnostic pre-assessment by giving the class two problems – one of low and the other of medium difficulty – to work through before they study the material. Use the results to gauge the best level at which to begin instruction.
2. Divide the class into small groups and ask the students with elegant, well-documented responses to explain their solution processes step by step to those who had difficulties.
3. Ask one or two students who documented their (successful) solutions especially well to lead the class through one of their responses, step by step.

4. Use this assessment as a regular part of homework assignments. For example, the teacher might ask students to document one problem in the homework set or one problem on each quiz or test. Students can be given credit for doing a thorough job of documenting, without receiving a grade.