FLIPPING THE DEVELOPMENTAL MATHEMATICS CLASSROOM:
AN ACTION RESEARCH STUDY

A Dissertation in
Adult Education

by
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ABSTRACT

This action research study explored a constructivist, flipped classroom approach to teaching developmental mathematics. This study was developed in response to a concern regarding a lack of success in developmental mathematics. Throughout the study, adult developmental learners were required to watch video lectures prior to attending class. Class time was reserved for supporting and enhancing the out of class learning with collaborative in-class learning activities.

The theoretical framework for the study was grounded in constructivism and supported by a community of mathematical inquiry. Data collection consisted of a beginning of semester survey, minute papers, weeks four and ten surveys, end of semester interviews, researcher journal, and faculty evaluations.

The findings of the study were grouped into two sections. The first section focused on the qualitative findings and is organized into seven thematic sections. The first qualitative section discussed the student’s beliefs about math, specifically their struggle and frustration with the subject. The next finding, ongoing transformations, examined the student’s emerging change in perception, how they went from hating math to liking it, and the enjoyment that the adult developmental learners found in the class. The third finding focused on the shared connections the adult developmental learners were developing with each other while the fourth finding discussed the enhanced independence that the adult developmental learners were acquiring. Learning in the flipped classroom was next and noted that the video lectures gave adult developmental learners time to process mathematical ideas, allowed for flexible instruction, provided a
lesson preview and became a study tool for the adult developmental learners. The sixth finding was related to the community of math inquiry theoretical framework and highlighted the collaboration with peers, dialogue and discussion, different perspectives, relaxing climate, and the challenges of group work. The final qualitative finding focused on the way that I teach including my thorough explanations, teaching presence, and the learning aids incorporated within the course. The second section of findings highlighted the quantitative findings. These findings resulted from the weeks four and ten surveys as well as the faculty evaluations.

This study concludes with a discussion of the findings in relationship to the theoretical frameworks, presents implications for developmental mathematics and adult education, and includes suggestions for future research.
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CHAPTER 1

INTRODUCTION

This chapter provides an overview of an action research study focused on a flipped classroom approach to teaching developmental mathematics. A flipped classroom model of teaching shifts the lecture outside of class via electronic media and uses in-class time to process and apply concepts from the lecture through individual and collaborative activity. Included in this chapter is the background of the study, problem statement, purpose, guiding research questions, overview of the theoretical framework, and research methodology. The chapter concludes with definitions, assumptions, and limitations of the research.

Background Information

I teach developmental mathematics to underprepared students at a public 4-year institution. I am a member of the Department of Academic Enrichment, which provides remediation coursework in reading, writing, and mathematics, as well as tutoring services to undergraduate students in a variety of courses. We also provide counseling services to ACT 101 students. ACT 101 students are loosely defined as economically and educationally disadvantaged. Part of the funding we receive for our program comes through a grant for ACT 101 which is a Pennsylvania state program. My department is considered a centralized developmental education program because the disciplines are all in the same department, rather than immersed throughout the campus community in various academic departments. For instance, in some institutions, developmental mathematics is housed in the mathematics department, developmental writing in the English department, and so on.
Students are admitted to the institution through the regular admissions process or through the ACT 101 program. ACT 101 students only gain admission to the university after proving themselves successful in the six-week summer program. Both regular admission and ACT 101 students are placed into mathematics courses based on their SAT score and their score on the Accuplacer placement exam. Students can be placed into Introductory Algebra, Intermediate Algebra (which are developmental courses) or a variety of college level math courses. Numerous ACT 101 students require a developmental mathematics course or two, as do many regular admission students. The grades the students earn in the developmental math courses (Introductory and Intermediate Algebra) affect their GPA but are not factored in as credits towards graduation requirements. Each of the courses offered in the Department of Academic Enrichment are held Monday, Wednesday, and Friday for fifty minutes each or on Tuesdays and Thursdays for seventy-five minutes.

As a developmental mathematics educator, I work with an at-risk population of underprepared students. These students not only lack basic skills in reading, writing, and mathematics, but most also lack study skills and are not acclimated to an academic environment. In addition to learning course content, developmental students are also learning the culture of academia. There is an urgency in helping students to be as successful as possible in developmental mathematics because the longer a student is enrolled in developmental mathematics courses, the less likely he is to graduate (Stigler, Givvin, & Thompson, 2010). I have the challenge of teaching two years of high school algebra in two short semesters. I must also prepare the underprepared student for a variety of college level math courses that they might need to take to satisfy their general
education and major requirements such as College Algebra, Statistics, or Math Thinking, which develops quantitative reasoning and explores the use of mathematics in solving problems and making decisions, among others. Unfortunately, most developmental students have struggled to learn mathematics, and the way that I currently teach does not allow them the time and space to think and process ideas.

Prior to this study I predominantly taught using lecture based methods. I would present mathematical concepts and ideas in class and provide several examples to illustrate and support those ideas. I have found that adult developmental learners are not able to process the incoming information at the same time that they are attempting to transfer notes from the board into their notebooks. Simms and Knowlton (2008) stated that, “even though students are taking notes about solving math problems, they are not developing a meaningful understanding of mathematical processes” (p. 22). I expected my students to process and apply complex mathematical ideas while they simultaneously transcribed notes. Later, when students completed homework, they struggled to apply the concepts taught during class. I was concerned that a contributing factor to students’ lack of success in developmental mathematics was my teaching model. In response to this concern I was interested in promoting a constructivist environment in my classroom by reversing the in-class processing expectation with out-of-class application. This involved using the flipped classroom which utilizes educational videos to provide background knowledge and introductory instruction outside of class. During class students have the opportunity to engage with the content presented in the videos and receive feedback and assistance from their peers and the instructor.
Research regarding the flipped classroom has exploded in recent years. A search of flipped classrooms reveals numerous empirical articles. Of the studies examined, the majority occurred in upper level undergraduate courses and graduate level courses. Students enrolled in those courses are typically prepared for college level work and likely do not experience the learning challenges that underprepared students face. The literature does not tell us how economically and educationally disadvantaged adult developmental students perceive the impact of the flipped classroom. No research currently exists on an at-risk population of adult developmental learners in higher education.

Although research on the flipped classrooms has grown significantly, there are concerns implementing the flipped classroom within developmental mathematics. A flipped classroom requires more responsibility from students (Foertsch et al., 2002) due to their obligation to watch lecture videos outside of class. Developmental learners are more dependent on faculty and need to be led more than those students that are academically prepared (Wambach & Brothen, 2000). Will adult developmental mathematics students accept and commit to this responsibility? Will they engage with the video lectures? Also, much of the class time in a flipped classroom is devoted to students working collaboratively to complete the required in-class assignments (Tucker, 2012). Will adult developmental students embrace the collaboration, stay on task, and work productively within groups? Can adult developmental mathematics students learn in a flipped classroom? Will students get discouraged with the flipped classroom? What does a flipped classroom look like in a developmental mathematics classroom serving the most at-risk population in higher education? The concerns and questions noted above led
to selecting action research as the methodology most likely to assist me in improving the current teaching/learning environment.

Developmental Education

The National Association for Developmental Education (NADE) proclaims that the purpose of developmental education is “helping underprepared students prepare, prepared students advance, advanced students excel” (NADE, n.d.). Developmental education is typically thought of as remediation coursework in reading, writing, and mathematics with the intent of supporting and assisting students who are not adequately prepared for college level work. However, developmental education also consists of tutoring, academic advising, counseling, and learning centers. It is primarily focused on having the developmental learners persist to graduation (Burley, Butner, & Cejda, 2001). Although developmental students are underprepared, that does not imply that the student does not have the ability to be successful in college, simply that the student will require assistance in preparing for the level of work expected (Boylan, 1999). Developmental education is important to our society as it provides access to a degree for those individuals who are educationally marginalized. Casazza (1999) noted that, “absolutely nobody – not one single person – should feel sentenced to a lifetime of exile from the world of learning. It is a matter of human dignity, in fact, a matter of real democracy” (p. 18).

Developmental courses are designed to remediate students so that they may pursue their career and life goals. These courses do not count for graduation credit; they do not fulfill general education or major requirements. The courses do, however, get factored in the student’s GPA. It has been reported that students in need of remediation
drop out of college at a much higher rate than students not requiring remediation (Burley, Butner, & Cejda, 2001). The rate of retention for developmental students is also negatively affected by the number of developmental courses the students often need to complete (Bailey, Jeong, & Cho, 2010). Attrition is not only attributed to a lack of preparedness but also to a host of other reasons such as self-doubt, lack of study skills, familial distractions, lack of perseverance, and adult responsibilities, among others (Damashek, 1999).

Underprepared adult students pursue degree programs because education is valued in our society and it represents an opportunity for a better life not only for themselves but also for their families. The numerous long term positive effects of educated citizens and their benefit to society can be found throughout the developmental education and adult education literature. Developmental education benefits society as it enables more citizens to attain a college degree (Waycaster, 2001). Those individuals seeking opportunity, who have the desire to earn a degree, but lack the necessary skills, would remain marginalized and disadvantaged without the services that developmental education offers. According to Hunter Boylan, Director of the National Center for Developmental Education at Appalachian State University in North Carolina, “Developmental education helps them [underprepared students] become stronger students. Developmental education helps them make better use of their talents. Developmental education gives them the opportunity to be successful” (Boylan, 1999, p.4).

Much of the research in developmental education focuses on assessment, placement, retention, and success rates of students and the majority of the research occurs
in community colleges. Although the research highlights important information regarding developmental students, such as which courses students placed into, which courses they completed, when students stopped taking developmental courses, and that the more developmental courses a student needs to take the more likely he is to drop out (Bailey, Jeong, & Cho, 2010). Less is known about the population of adult developmental learners at four-year institutions.

Developmental Mathematics

Mathematics is the deficiency that is most influential in determining the successful completion of the degree program (AMATYC, 1995; Duranczyk, 2007; Fike & Fike, 2007). Fike and Fike (2007) found that students are less prepared in mathematics than any other subject. Unfortunately, mathematics is “the most difficult area to remediate” (Burley et al., 2001, p. 778). Only half of the students who enroll in developmental mathematics complete it successfully (Fike & Fike, 2007).

Developmental mathematics courses are intended for students who are not prepared to enter college level mathematics courses, such as College Algebra, Introduction to Statistics, Business and Economics Mathematics, Mathematical Thinking, or a host of other courses. Students who are placed into the lowest level developmental mathematics class are facing an especially difficult obstacle. Depending on the institution and the number of levels of developmental mathematics, students could be enrolled in developmental mathematics for two years. Some institutions only support Intermediate Algebra, the gateway course prior to college level mathematics courses. Other institutions have Introductory Algebra as well as Pre-Algebra and Basic
Mathematics. The longer a student is enrolled in developmental coursework, the less likely the student will persevere to graduation (Stigler, Givvin, & Thompson, 2010).

Students often enter mathematics classes with the mindset of memorizing the information given to them (Wheland, Konet, & Butler, 2003). Once the procedures are memorized, students practice several problems illustrating that particular procedure (Stigler, Givvin, & Thompson, 2010; Waycaster, 2001; Wheatley et al., 1995). Students are said to have learned when they can repeatedly solve the same type of equation but with different numbers (Elias & Merriam, 2005; Safford-Ramus, 2008). Essentially, students are being trained in how to manipulate mathematics without developing an understanding of mathematical applications. Braunfeld, Kaufman, & Haag (1973) remarked on the teaching of mathematics, “it is a disservice to students to train them simply to play a game with marks on paper – even if we could find means to do this superbly well” (p. 45). Over time, this cycle of teaching and learning creates the impression that mathematics is the meaningless manipulation of symbols, and that it holds little utility outside the classroom (White-Fredette, 2009). People can be taught to imitate math problems, but that does not demonstrate knowledge or understanding.

For adults, learning of this type is machine like, controlled, and views the learner in a simplified way that is devoid of emotion (Elias & Merriam, 2005). Teaching in this way creates passive learners that have little time to engage in mathematical reasoning and higher order thinking necessary for sustained mathematical success. This model of learning requires students to attempt the deeper learning on their own, outside of class, with little to no feedback directing them in their thinking. Many adult students are busy
with jobs, family responsibilities, and other constraints on their time. Mathematics simply becomes courses students have to take to graduate (Stephens, 1988).

A student’s self-confidence and belief about themselves and their ability to learn was shown to affect their level of success, especially with respect to developmental mathematics (Duranczyk & Higbee, 2006; Duranczyk, 2007; Duranczyk, 2008). A positive experience with developmental mathematics increases students’ confidence in learning mathematics (Duranczyk, 2008). Students who have a successful developmental experience are more likely to experience success in subsequent courses and are more likely to persist and earn a degree (Penny & White, 1998). Moreover, students who successfully completed developmental mathematics courses were just as prepared as their non-developmental counterparts in subsequent college level math courses (Penny & White, 1998; Waycaster, 2001; Wheland et al. 2003).

Teaching through passive and decontextualized, lecture-based teaching often leads developmental students to memorizing mathematics and focusing on surface learning rather than understanding of mathematical ideas. This approach to teaching rarely provides adequate time for students to process incoming information and, when they do process, it is usually in isolation with little to no opportunity for collaborative learning. By rethinking the dominant approach to teaching developmental mathematics and embracing a constructivist theory of learning, students are supported to successfully complete developmental mathematics. von Glasersfeld (1996) notes that, “the task of the educator is not to dispense knowledge but to provide students with opportunities and incentives to build it up” (p.7). A constructivist approach provides adult developmental students with the opportunity to process information and make meaning out of the ideas.
It focuses on understanding. A theoretical shift needs to occur in developmental mathematics classrooms where students are given the opportunity to think about and create their own mathematical knowledge as opposed to mindlessly practicing routine problems.

Flipped Classroom

Jonathan Bergmann and Aaron Sams, science teachers credited with pioneering the flipped classroom, describe the flipped classroom in this manner, “the one unifying characteristic of all flipped classrooms is the desire to redirect the attention in a classroom away from the teacher and onto the learners and the learning” (Bergmann & Sams, 2012, p.96). That shift occurs in a flipped classroom by switching out of class activities with in-class activities (Lage, Platt, & Treglia, 2000; Wentland, 2004). This model of teaching moves lectures outside of class via pre-recorded video media and shifts homework and other out-of-class activities in-class. Through this shift, students are now able to receive assistance and feedback from classmates and/or instructors (McDaniel & Caverly, 2010).

The flipped classroom is more efficient (Bergmann & Sams, 2012) as time normally devoted to lectures can be re-imagined into other more active learning strategies. This re-structuring increases contact time between faculty and students as well as among students which increases students’ motivation to learn (Lage et al., 2000; McDaniel & Caverly, 2010). The interactive nature of the flipped classroom supports a social constructivist framework (Bergmann & Sams, 2012) and engages students in higher order thinking about mathematics (McDaniel & Caverly, 2010).
Educators have identified benefits to teaching with this model. They noted that all students are able to receive assistance in the flipped classroom, not just those students that are the most verbal or motivated. The flipped classroom enables faculty to speak with every student during each class, and they are able to provide more one-on-one help to weaker students (Bergmann & Sams, 2012; Tucker, 2012). The extended interactions between faculty and students have helped to clarify misunderstandings prior to leaving class for the day (Lage et al., 2000). Regarding the flipped classroom, instructors noted that the Microeconomics class at Miami University “course was considerably more stimulating to teach” (Lage et al., 2000, p. 37). Faculty at the University of Wisconsin-Madison stated that it was more interesting to teach in a flipped classroom because, “the material is not simply fed to students in a one-way monologue” (Foertsch et al., 2002, p. 270). Educators also noted that preparation time has increased, especially in the beginning, with a flipped classroom (Cummins-Sebree & White, 2014; Moran & Milsom, 2015). They must invest time in creating and/or identifying beneficial video lectures and then on structuring worthwhile classroom activities which can take a considerable amount of time to complete.

The flipped classroom has been shown to be equally as valuable for students. Students like learning from peers and felt the flipped classroom was useful and helpful overall (Clark, 2015; Foertsch, Moses, Strikwerda, & Litzkow, 2002; Strayer, 2012). Specifically, students liked having the perspective of their peers on the problem solving process and application of lecture content in an Engineering Problem Solving using Computers course at the University of Wisconsin-Madison (Foertsch et al., 2002). They found the group work beneficial because if they knew something well it helped them to
learn it better when they explained it to a group member (Clark, 2015; Foertsch et al., 2002). Additionally, students liked the in-class activities and labs because they normally would have completed them on their own outside of class and struggled but the collaboration between fellow students and instructor enabled them to complete the work (Foertsch et al., 2002). One student noted that, “as for the class itself, I loved the way it was run! The groups were very effective – it helped to have your peers explain things to you in a different way that sometimes made more sense. Also, it was easier to get to know your classmates and made for a very comfortable environment. I liked the ‘hands on’ approach” (Lage et al., 2000, p. 35).

Although students like learning in the flipped classroom, it requires a higher level of responsibility on the part of the student (Foertsch et al., 2002; Gunyou, 2015; Lage et al., 2000; McDaniel & Caverly, 2010). Students must be diligent about watching the lectures outside of class so they are prepared during class. The ability to watch the lectures when it was best for them and their schedule was especially appealing to adult students as they could work around their busy schedules (Foertsch et al., 2002; Gunyou, 2015; McCallum, Schultz, Sellke, & Spartz, 2015). However, some students found it was more challenging to be attentive during the video lectures due to the informal, casual environment of their dorm room, coffee shop, or wherever they were at the time (Foertsch et al., 2002).

Unfortunately, much of the research on flipped classrooms exists on upper level students in higher education, not an at-risk population. What is the perspective of the teacher and students in a flipped developmental mathematics class? What is the culture of the flipped classroom? What adaptations are necessary for the instructor or students in
developmental courses? What participation challenges are found in a flipped classroom? What improvements can be seen within the course or with the students? What problems/issues have developed? How do you keep the students on-task daily? There are too many unanswered questions about what goes on daily in the classroom as well as what the flipped classroom looks like in developmental mathematics.

Problem Statement

On average, 40% of my students each semester do not earn a C or better in the developmental courses I teach. Departmental policy demands that regular admission students must earn a grade of D or better in developmental coursework to advance to college level math courses and ACT 101 students must earn a grade of C or better. I realize that I am not to blame for all of those failures. Developmental students are a diverse population of learners. Some adult developmental learners are recalcitrant and are not studious when it comes to attending class and completing coursework. Other students are resistant and resent the idea of being forced to take a class that will affect their GPA but does not count for graduation credits. At the same time, there are adult developmental learners that appreciate the opportunity to refresh some of their skills before pursuing college level courses. Regardless of the mixture of students I am teaching, I shoulder some of the blame for why two out of every five students must repeat developmental math courses.

I begin class each day with notes relevant to the day’s lesson organized in outline form. The class notes commence with necessary definitions, theorems, or properties related to the objective. The following section of notes details procedural steps for the mathematical concept. I conclude the class notes with several examples carefully chosen
to illustrate the numerous variations the students might encounter. During the example problems section, I complete all examples at the board, typically explaining each step of the process as I go.

On any given day, my students spend about fifteen minutes copying the first two sections of notes into their notebook. The students have little time to think about the mathematics, as they are busy working to keep pace with me and copy the notes into their notebooks. I have always felt that it was important for me to provide my students with copious notes for them to use as a resource to assist in homework completion and as a study guide. However, I feel that too much class time is wasted with students copying notes.

My teaching practice is structured, lecture based teaching and assumes that students will understand a mathematical concept that I present via my constructed understanding. I essentially teach the way that I was taught. Like many teachers, I learn quite well when taught in this traditional way. But the passive environment that I have created does not encourage students to collaborate or engage in discourse. Regardless of how well I explain my perception of a concept, it may not make it easier for most of my students to learn. As von Glasersfeld (1996) noted that, “the task of the educator is not to dispense knowledge but to provide students with the opportunities and incentives to build it up” (p.7). My students wait for me to distribute my mathematical knowledge to them for absorption. A teaching/learning environment organized in this manner does not encourage the students to utilize reasoning skills and think about mathematics. Instead, students focus on survival and memorize their way through mathematics. When the emphasis of learning is on memorization, little effort is invested in making meaning out
of mathematics and developing an understanding of underlying concepts. I have come to the conclusion that I need to work towards improving my teaching practice in an effort to help more developmental students achieve success.

Purpose of the Study

The purpose of this action research study is to explore a constructivist, flipped classroom with developmental mathematics students.

Research Questions

1. How can a flipped classroom be successfully implemented within a developmental classroom?
2. How does a flipped classroom, from the perceptions of adult developmental learners, promote a community of math inquiry in a developmental mathematics classroom?
3. What are the perceptions of adult developmental learners concerning the flipped classroom and the impact on learning for developmental mathematics?
4. What practical strategies were most effective at facilitating a flipped classroom from the students’ and faculty member’s perspective?
5. What is the degree of satisfaction of the flipped classroom from the student’s perspective?

Theoretical Framework

The theoretical framework determined to be most appropriate for informing this study is constructivism, which serves as the grand framework for the study. In order for a student to learn a subject or discipline or concept with understanding, the individual must think about the topic under study and make sense of the information in their own minds
Constructivism encourages students to create their own understanding. Through this process of developing their own understanding, students are also creating ownership of an idea which is constructivism (Hyslop-Margison & Strobel, 2008). A constructivist approach to teaching developmental mathematics will be explored via a flipped classroom.

This study will be guided by an additional theoretical framework, community of mathematical inquiry. A community of mathematical inquiry is an environment that encourages dialogue and discussion among students (Goos, 2004). Every student in the classroom environment is a component in the learning process (Hunter, 2010). The flipped classroom provides students with the opportunity to discuss ideas and receive immediate feedback to guide their knowledge construction. An overview of both frameworks is provided in the following sections.

**Constructivism**

Constructivism declares that learning is an active process where the individual is engaged in thought and creating their own meaning related to the topic under study (Powell & Kalina, 2009). Constructivism builds knowledge from the learner’s perception and previous personal experience, which are varied and dependent upon each learner’s ontological assumptions (Fosnot, 1996; Hyslop-Margison & Strobel, 2008; Patton, 2002; von Glasersfeld, 1996).

Constructivism asserts that learners manipulate incoming information to create meaning based upon their personal experience and social interactions (Draper, 2002). Essentially, knowledge is constructed through integration with other ideas and the personal meaning that is attached to each idea (Carpenter & Lehrer, 1999).
Constructivism encourages students to create their own understanding of concepts and to make sense of those concepts (Hyslop-Margison & Strobel, 2008). This is particularly appropriate for adult learners because they relate incoming information to their life experiences and adults use their life roles to create meaning out of the content (Kasworm, 2008).

Social interactions and personal experience are central to this theory of learning as they contribute to the construction of knowledge (Gordon, 2009). Powell and Kalina (2009) noted that, “teachers and students must communicate to convey information and for learning to take place” (p. 247). Learning occurs in classrooms from teacher-student interaction, student-student interaction, and personal reflection (Gordon, 2009). Those social experiences expose students to various perspectives and interpretations (Powell & Kalina, 2009). The learner adapts the ideas of others, points of view, etc. to how it works for them (von Glasersfeld, 1996). Brooks and Grennan Brooks (2007) noted that,

Learners control their learning. This simple truth lies at the heart of the constructivist approach to education. . . Students must be permitted the freedom to think, to question, to reflect, and to interact with ideas, objects, and others – in other words, to construct meaning (as cited in Auger & Rich, 2007, p. 40-43).

Knowledge is created by making associations, classifications, and organizing incoming information with personal experience (Fosnot, 1996).

Due to the influence of social interaction and personal experience on knowledge construction, an individual’s intelligence is not predetermined (Gordon, 2009). People are able to continue learning and creating knowledge. The incorporation of constructivist
teaching practices increases student’s self-confidence in mathematics (Wheatley et al., 1995) and students in constructivist classrooms appreciated the ability to be more involved in the learning process (Gordon, 2009). Leading mathematical associations such as the National Council of Teachers of Mathematics (NCTM) and the American Mathematical Association of Two-Year Colleges (AMATYC) endorse the inclusion of constructivist teaching practices.

A concept pivotal to constructivism that differs from other theories of learning is that there is no absolute truth or ultimate way of knowing when constructing knowledge because we make knowledge from our perceptions which are varied and dependent upon each learner’s personal experience (Fosnot, 1996). Therefore, the adult developmental learners and their experiences, teacher, and environment actively contribute to the learning and what is learned in one situation could be different than that which is learned elsewhere. von Glasersfeld (1995) characterizes learning in context as,

In the endeavor to arrive at a viable model of the student’s thinking, it is important to consider that whatever a student does or says in the context of solving a problem is what, at the moment, makes sense to the student. It may seem to make no sense to a teacher, but unless the teacher can elicit an explanation or generate a hypothesis as to how the student has arrived at the answer, the chances of modifying the student’s conceptual structures are minimal. (as cited in Wheatley et al., p. 15)

Constructivist learning is influenced by cultural and social factors (Liu & Matthews, 2005).
As with any other theories of learning, constructivism has its own assumptions and claims. Constructivism discounts memorization as a learning tool as well as that of other forms of passive learning. Constructivists make the argument that the only way to learn is through active knowledge creation (Hyslop-Margison & Strobel, 2008) based upon individual (personal experience) and social interactions (synthesis of ideas) (Cobb, 1996; Hyslop-Margison & Strobel, 2008). Constructivists do not value lecture as having a place in its theoretical underpinnings. However, students can listen to an instructor’s lecture, make sense out of it, and work it into their existing knowledge structure. Gordon (2009) describes the union of lecture teaching and constructivism as, “a good constructivist classroom is one in which there is a balance between teacher and student directed learning, and one that requires teachers to take an active role in the learning process, including formal teaching” (p. 47). It would be difficult to learn higher level mathematics without some lecture. Lecture can have a place in constructivism.

The educator’s role in a constructivist classroom shifts from center stage, the expert with knowledge to be transmitted, into a facilitator encouraging students as active co-constructors of knowledge and understanding (Fennema, Sowder, & Carpenter, 1999). Constructivism assumes that students will naturally engage in dialogue and social interaction to the degree that it is beneficial and leads to the construction of knowledge. Inherent to constructivism is promoting critical thinking among students. Powell and Kalina (2009) stated that, “if they [students] think critically, they will walk away with personal meaning that was constructed on their own” (p.245). This theory of learning demands that students become active learners that engage with the content.
A community of mathematical inquiry (CMI) encourages dialogue and discussion among students. A CMI contains learners at all levels of cognitive ability and the interaction between learners with those varying levels increases learning (Goos, 2004). A CMI claims that students learn from sharing and listening to the ideas of others and then forming those ideas into a collective understanding (Kennedy, 2009). Requiring students to justify their thoughts and ideas is an important component of a CMI. A CMI occurs within each student’s zone of proximal development and the students scaffold each other’s learning through dialogue (Kennedy, 2009). Students scaffold each other’s learning through questioning, clarifying, explaining, and re-thinking (Kennedy, 2009). Students are able to scaffold each other’s learning as each learner has formed different perspectives and understandings of the concept (Goos, 2004). Students would be just outside the zone of proximal development without the scaffold assistance from their peers (Kennedy, 2009).

Educators that want to transition into a CMI should model mathematical thinking, problem solving, and enthusiasm for mathematics (Goos, 2004). An educator in a CMI evolves into more of a facilitator and less of a lecturer (Kennedy, 2009). Creating a CMI is a challenging task for teachers (Hunter, 2010). In order to effectively change, most educators need to change their perception of the classroom and the roles of both the teachers and the students (Hunter, 2010). A paradigm shift is necessary regarding teacher’s perceptions. Educators attempting to develop into a CMI may encounter resistance from students and parents as this model differs from preconceived notions about the way mathematics should be taught (Hunter, 2010).
A CMI classroom is a learning community where each student is a component in the learning process (Hunter, 2010). The CMI classroom values and respects all perspectives and ideas but also encourages argumentation (Kennedy, 2009). The process of arguing naturally engages students in assimilating various ideas scaffolded by their peers. Differing ideas and the resolution of those different ideas is an important component of a CMI (Kennedy, 2009). The collaborative learning in a CMI becomes a pedagogical tool (Hunter, 2010).

Students participating in a CMI changed in how they interacted with each other, the teacher, and their view of mathematics (Hunter, 2010). Hunter (2010) found that “they repositioned themselves in the community and assumed different roles and responsibilities” (p. 406). Students became comfortable enough that they were able to communicate directly with their peers and no longer felt the need to involve the teacher in the discussion (Goos, 2004). They also began to take ownership and accept responsibility for their learning (Goos, 2004). Students felt that explaining and justifying their ideas helped them to understand the mathematics they were studying (Goos, 2004). One student commented, “if you can explain it to someone else it means you know” (Goos, 2004, p. 272).

Methodology Overview

This action research study was guided by a qualitative research paradigm. Qualitative research is focused on understanding a problem or issue (Merriam & Simpson, 2000; Patton, 2002; Willis & Neville, 1996). It seeks to understand a problem or issue and respects the complexity of the situation and context whereas quantitative research rejects the idea that a context influences the research (Creswell, 2009;
Hathaway, 1995; Patton, 2002). The information gained from qualitative research is rich as it allows for insight from a specific perspective or context (Patton, 2002; Willis & Neville, 1996). Unlike quantitative research which touts observable, absolute truths, qualitative inquiry represents many truths which may or may not be observable and that emerge from the data. Qualitative researchers believe that, “reality is constructed by individuals in interaction with their social worlds” (Merriam & Simpson, 2000, p. 97). Truth is determined by the participants based upon how they see, create, and perceive it to be within the specific context.

Researchers are the heartbeat of the research because they are “the primary instrument for data collection and analysis” (Merriam & Simpson, 2000, p. 98). The researcher is not simply an observer in this paradigm, but is actively involved in all aspects of the research (Hathaway, 1995). Qualitative researchers are immersed in the context and environment, working to understand the phenomenon under study. Knowledge will be socially constructed between the researcher and participants which becomes context specific and should not be generalized across large populations (Merriam & Simpson, 2000; Patton, 2002; Willis & Neville, 1996). However, my struggles and triumphs have the potential to influence others as they may be able to relate to similar experiences. Although the results of this study are not generalizable, there are portions that can be adapted and modified to various other contexts and situations.

According to Carr and Kemmis (1986), “action research is research into practice by practitioners for education and those involved in the practices which constitute education” (p. 199). Action research is focused on problems and issues inherent in the environment with the goal of encouraging participation to resolve those problems and
empower people (Kuhne & Quigley, 1997). It is constantly evolving and being shaped to meet the ever-changing dynamics of those being studied (Kemmis, 2008).

Action research’s goal is not to find an easy solution to the problem(s), but to empower practitioners to discover potential solutions or work towards improving their practice (Carr & Kemmis, 1986). Gergen and Gergen (2008) described action research as, “it [action research] says to the audience ‘here is my story of the good’, as opposed to ‘I proclaim the universal good’” (Gergen & Gergen, 2008, p. 165). It is deliberate as it seeks to understand the teacher’s practice, context, and situation with all of its assumptions, values, and bias (Carr & Kemmis, 1986). True examination allows teacher researchers to creatively explore alternative ways to achieve educational success (Carr & Kemmis, 1986). Effective change can occur by seeing one’s practice in detail and bringing forward the teachers assumptions in an effort to question them and to better understand their own practice (Carr & Kemmis, 1986; Kincheloe, 1991).

Action research is a cyclical process of planning, acting, observing, and reflecting (Kuhne & Quigley, 1997). During the planning phase the teacher researcher works to understand the problem she is trying to solve by viewing the problem from different perspectives and questioning assumptions that affect the practice of teaching (Kuhne & Quigley, 1997). The teacher researcher must also clearly define the problem, identify potential changes to make in practice, and determine how the research will be evaluated (Kuhne & Quigley, 1997). An action researcher “plans thoughtfully, acts deliberately, observes the consequences of action systematically, and reflects critically on the situational constraints and practical potential of the strategic action being considered” (Carr & Kemmis, 1986, p. 40). It encourages the teacher-researcher to interrupt the
research in an effort to make improvements to the practice (Kemmis, 2008; Merriam & Simpson, 2000).

A successful action research study assumes that the researcher will complete thorough interpretations with observations noting her own bias and how that influences the study. The researcher must be reflective and action research assumes that will naturally occur. Within an educational context, the participants are usually students enrolled in the class. It is taken for granted that students will participate wholly, freely, and honestly when the researcher ultimately controls all final grades for the course. Action research is also based upon the premise that change and growth will occur and the situation will improve as a result of the action research.

Action research was deemed the most appropriate methodology to study a constructivist, flipped classroom approach to teaching developmental mathematics. First, there was a need to improve the practice of teaching developmental mathematics. In an effort to improve my teaching, I needed to develop a thorough understanding of my practice and the problems in it (Creswell, 2009). Looking for a simple cause-effect relationship would not illuminate problems within the practice. Second, when improving practice there is a need to be able to change the research as the study is advancing in order to meet the needs of the teacher-researcher and the students (Kemmis, 2008; Merriam & Simpson, 2000). It was also imperative to respect the context of developmental mathematics and not remove it from that environment as both the context and the environment influence developmental mathematics (Creswell, 2009; Hathaway, 1995). Since the objective was to improve teaching practice, there is a compelling need
to understand the researcher’s values and bias and how they have influenced the practice of teaching (Creswell, 2009; Merriam & Simpson, 2000).

As a developmental mathematics practitioner, my perspective is valuable and provides knowledge to the field as my experience lends insight and creates knowledge valuable to developmental education (Wicks, Reason, & Bradbury 2008). Action research is “active experimentation” (p. 19) and allows me to utilize the practical experience and knowledge I have acquired through my years of teaching developmental mathematics. It is unique as it values and incorporates the perceptions and intuitions of the teacher (Kincheloe, 1991). The teacher herself knows best what to research and has the best understanding of the context and the students. Research and its findings are not valuable unless they can be implemented into classrooms immediately (Carr & Kemmis, 1986).

This action research study was implemented during fall 2014 within one section of Intermediate Algebra, which is limited to 25 students. This course was selected because I teach two of those courses, and if the need would arise, I could compare the traditional lecture class to the flipped class. Throughout the study, I maintained a teacher journal to document my perspective of the flipped classroom. Students were asked to complete surveys and questionnaires at the beginning of the semester and at designated points throughout the semester. Semi-structured interviews were conducted at the end of the semester.

Significance of the Study

Research has shown that many students enrolling in postsecondary education are not academically ready for the coursework they will encounter in college (Fine, Duggan,
Students are less prepared in mathematics than any other subject (Fike & Fike, 2007). Regrettably, mathematics is “the most difficult area to remediate” (Burley, Butner & Cejda, 2001, p.778) and only half of the students who enroll in developmental mathematics complete it successfully (Fike & Fike, 2007). Mathematics is also the deficiency that is most influential in determining the successful completion of the degree program (Fike & Fike, 2007). Unfortunately, students in need of remediation dropout of college at a much higher rate than students not requiring remediation (Burley, Butner, & Cejda, 2001).

The literature shows that there is a need to investigate alternative ways of teaching developmental mathematics within the traditional classroom structure. Developmental mathematics at my institution is predominantly taught through lecture teaching or using web based software such as MyMathLab. Both methods are driven by behaviorist teaching practices that implement drill and kill style teaching and learning. To date, no action research studies have been found that investigates an instructor’s transition from behaviorist drill and kill teaching into a constructivist, flipped classroom. The results of this study have the potential to contribute to several fields of study, such as Adult Education, Developmental Education, and Math Education.

An examination of adult education literature reflects a lack of empirical studies pertaining to adults in developmental programs or coursework. Numerous studies exist regarding adults in higher education but relatively few speak specifically to adults in developmental courses. Developmental education research fails to focus on the adult learner and make the connection between the adult learner and adult education literature. There is a paucity of research about adult students in developmental education. Few
articles even mention adults. A handful of studies explicitly discuss adult students as part of the population, but it appears as though it is more of an afterthought. This action research study is likely to connect with other adult educators who may be considering a change in their own teaching practice.

This study is significant as it offers insight on teaching developmental mathematics. Information gained from this study can directly influence designs regarding course development and teaching practice. This study contributes to our understanding of how to teach developmental mathematics as well as how educators foster change in their practice. In particular, this research helps other practitioners make decisions regarding how an educator can transition to a constructivist, flipped classroom given the prescribed curriculum and numerous institutional constraints. Transitioning from a behaviorist teaching practice into a constructivist practice also enhances student learning. Student success is encouraged as the classroom moves from one of passive learning to a constructivist environment which will hopefully alleviate student frustration rather than contributing to it.

This study is also personally significant as 40% of my students are not successful (earned a grade of C or higher). There is a need to improve instruction as many students are not successful. Typical lecture based teaching is not effective for my students. As a result, there is a concern about the way I teach developmental mathematics. This action research study challenged me and allowed me to understand the problems inherent in my practice. My practice has broadened to integrate active learning and transitioned into a constructivist, flipped classroom. Additionally, action research engages me as a
practitioner in research about my practice which parallels my scholarly growth responsibilities at my institution.

Assumptions

As with any study, there are assumptions based upon the structure and foundation of the study. The assumptions made by the author of this study are as follows:

1. My current classroom structure and teaching practice does not meet the needs of the learners.
2. A constructivist, flipped classroom will create a more effective teaching and learning environment than a traditional, lecture based teaching approach.
3. Constructivism is more effective than lecture teaching and that students will prefer being active constructors of knowledge rather than being passive learners.
4. Through action research I will be able to adequately examine my practice for improvement.
5. Developmental students will find the action research project enjoyable and meaningful and that they will be willing to participate in the study to improve the teaching and learning environment.
6. Students will provide honest, evaluative feedback regarding learning developmental math within a flipped classroom.

Limitations

There are several limitations considered in light of this study. Although the research is focused on adult, developmental math students, there may be only one adult student (age 25 or older) enrolled in the course. Due to the limited number of adult
students (as defined by age) enrolled in my courses; the scope of adult developmental learners was expanded to include those learners with adult responsibilities. Questions four through eleven on the beginning of semester survey (Appendix C) were included to determine the participants adult status: minimally nontraditional, moderately nontraditional, and highly nontraditional as defined by the National Center for Education Statistics (2010).

This study is very context specific as it is set in a centralized department of developmental instruction at a 4-year institution that enrolls small numbers of adult students each semester. The findings are tied directly to the context in which they are set. Therefore, the results are not reflective of all developmental mathematics students and are therefore not generalizable to other developmental populations. However, the results can be similarly applied elsewhere as determined by the reader.

Another limitation of this action research study is that I will not know who consented to participate in the study until after final grades have been awarded. As a result, I will be basing decisions on students who may not be participants in the study. I may also need to discard data from those students who did not consent to participate. Also, as the course instructor, I hold a position of power that may influence the participant’s free expression as I award the final grades in the course.

There is a tendency in self-study action research to make everything seem positive (Herr & Anderson, 2005). I have an idea how to solve some of the problems in my practice, but do not know if my interventions will be effective when utilized within my practice. I will need to address those concerns and acknowledge my presence in the study and build in self-reflection.
Although the ACT 101 program coordinated by my department is diverse, there is little diversity among the participants. Finally, there is a necessity to end the action research study as there are graduate school deadlines and semester schedules which in turn affects the number of interviews, meetings, etc.

Definition of Terms

*Action research* is a cyclical process of planning, acting, observing, and reflecting on one’s practice. Action research “is not research *about* education but research *for* education” (Carr & Kemmis, 1986, p.155). Action research’s goal is not to find a clean, easy solution to the problem(s), but to empower practitioners to discover potential solutions or work towards improving their practice. Effective change can occur by seeing one’s practice in detail and bringing forward the teachers assumptions in an effort to question them and to better understand their own practice (Carr & Kemmis, 1986; Kincheloe, 1991). Effective change can occur by seeing one’s practice in detail and bringing forward the teachers assumptions in an effort to question them and to better understand their own practice (Carr & Kemmis, 1986; Kincheloe, 1991).

*Active learning* posits that students are actively involved in the learning process rather than empty vessels waiting to be filled. Active learning encourages and supports constructivism through a collaborative classroom environment.

*Adult learners* are those individuals enrolled in postsecondary education who are usually responsible for themselves and sometimes dependent children, are their own financial supporters, and have other adult responsibilities (Kasworm, 2003).

*Community of mathematical inquiry* (CMI) is a learning community where each student is a component in the learning process (Hunter, 2010). Knowledge is constructed
in this framework via the sharing and synthesizing of each other’s ideas into one formulation (Kennedy, 2009). The focus of learning is not on memorization but rather understanding of mathematical concepts. A CMI promotes mathematical thinking and learning through questioning, justifying, and defending ideas presented by individual students (Goos, 2004).

Constructivism speaks to the ability of the individual to actively build knowledge and understanding. The knowledge and meaning is built by the individual through social interactions and personal experience. Information that comes in is integrated with the learner’s previous experience (Carpenter & Lehrer, 1999) through associations and classifications. The organization of those associations and classifications is what contributes to the construction of knowledge (Fosnot, 1996).

Developmental education supports and assists students who are not adequately prepared for post-secondary education as they work towards their pursuit of a degree (Boylan, 1999). Developmental education is typically thought of as remediation coursework in reading, writing, and mathematics. In addition to coursework, Boylan (1999) stated that developmental education also consists of tutoring, academic advising, counseling, and learning centers. He notes that there are three different types of developmental programs: centralized, de-centralized, and learning assistance centers. Centralized programs house all resources together and each component reports to a director. De-centralized programs are housed in their respective departments (developmental math in the mathematics department, developmental writing in the English department, etc.) and report to their individual departments. Learning assistance centers generally lack the developmental coursework and focus more on supportive
aspects of developmental education such as: study skills, tutoring, academic advising, and counseling.

*Developmental mathematics* courses are intended for students who are not prepared to enter college level mathematics courses, such as College Algebra, Introduction to Statistics, Business and Economics Mathematics, Mathematical Thinking, or a host of other courses. Developmental mathematics courses vary by institution but usually consist of Basic Mathematics (or Pre-Algebra), Introductory Algebra, and Intermediate Algebra, sequenced in that order. Institutions may have more or less courses than listed above.

*Flipped classrooms* are learning environments where normal classroom activities (lectures and direct instruction) occur outside the classroom and regular out of classroom responsibilities (homework, labs, etc.) take place in the classroom (Lage, Platt, & Treglia, 2000; Wentland, 2004). Bergmann and Sams (2012) described a flipped classroom in this manner, “the one unifying characteristic of all flipped classrooms is the desire to redirect the attention in a classroom away from the teacher and onto the learners and the learning” (p. 96).

*Successful completion* of developmental courses varies by institutions with many institutions determining successful completion as a grade of C or better in the course. Institutions determine whether students who do not earn a grade of C or better must repeat the course.
CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this action research study was to explore a flipped classroom with developmental mathematics students and the incorporation of a constructivist environment. This chapter is organized into four major sections: theoretical frameworks, developmental education, developmental mathematics, and flipped classrooms. The chapter begins with a discussion of the theoretical frameworks that inform this study. The theoretical framework begins with a focus on constructivism and narrows to a concentration on a community of math inquiry. The following three sections of the chapter reviews the current literature related to the study and emphasizes gaps in the literature, thereby supporting the rationale for this study. Altogether the included literature creates the backdrop to understand a flipped classroom within developmental mathematics.

Theoretical Frameworks

The theoretical frameworks that inform this study are constructivism and community of mathematical inquiry (CMI). Both frameworks are discussed in the following sections as well as in relation to the flipped classroom.

Constructivism

The following sections review the literature regarding the grand theoretical framework for the study, constructivism. The review will begin with the definition of constructivism, followed by a discussion of two different types of constructivism: cognitive and social. Next, consideration is given to the assumptions underlying this theoretical framework and implications for teachers.
**Definition of constructivism**

Constructivism is a theory of learning that informs how an individual learns (von Glasersfeld, 1996). It refers to the ability of the individual to build knowledge (Hyslop-Margison & Strobel, 2008) and began rising in popularity beginning in the 1980s (Liu & Matthews, 2005). Educators were in search of a learning theory that was less focused on the traditional behaviorist principles. Constructivism asserts that learners manipulate incoming information to create meaning based upon their personal experience and social interactions (Draper, 2002). This process actively engages all aspects of the mind to work together to synthesize incoming information (Vygotsky, 1962). Constructivism encourages active learning as opposed to passive learning which helps adult students to learn mathematics (Simms & Knowlton, 2008). Essentially, knowledge is constructed through integration with other ideas and the personal meaning that is attached to each idea (Carpenter & Lehrer, 1999). Constructivism encourages students to create their own understanding of the concepts, and to make sense of those concepts (Hyslop-Margison & Strobel, 2008). Adult students learn better when the course context is connected in some way to their personal or professional lives (Kasworm, 2008). This connection allows adult students to construct knowledge about the discipline (Kasworm, 2008).

The current learning environment in many mathematical classrooms has the teacher dispensing mathematical ideas and concepts for the students to learn. In this framework, students learn to practice the mathematics taught in class (Wheatley, Blumsack, & Jakubowski, 1995). People can be taught to imitate, (math problems, for instance) but that does not demonstrate knowledge and understanding (Vygotsky, 1962). Practice exercise after practice exercise does not encourage adult developmental learners
to construct knowledge about the mathematics they are practicing (Simms & Knowlton, 2008). In order for adult developmental learners to develop an understanding of mathematical concepts, they must do something with the information. Failure to do so leads to a lack of retention, misunderstandings of ideas, and an inability to transfer knowledge and learning to new situations. When students engage in the thought process, the process takes bits and pieces of information and organizes and groups them together based upon how the learner perceives they are alike or different (Vygotsky, 1962). This process naturally engages the learner in synthesis and analysis of ideas and supports a constructivist model of learning.

Individual knowledge construction is affected by cultural and social influences (Liu & Matthews, 2005). Adult students have diverse backgrounds and experiences and their previous life experiences influence their learning and educational experiences in the classroom (Kasworm, 2005; Kasworm & Marienau, 1997). Incoming information is related to their life experiences and adult use their life roles to create meaning of the content (Kasworm, 2008). Adult learners utilize a constructivist worldview to learn. For example, by mathematical definition, one interpretation of slope of a line is rise over run. That part of slope will not change over time, but how students think about and make sense of slope may differ. Some students may begin to process the idea of slope when considering that a wheelchair ramp increases a foot higher for every 12 feet in length or that a mountain has an 8% grade or that a house roof has a 9-12 pitch. Each student’s prior personal experience will affect their understanding of the idea and influence the meaning they ascribe to the concept of slope (Hyslop-Margison & Strobel, 2008).
Constructivism discounts memorization as a learning tool (Liu & Matthews, 2005) and encourages the learner to create an understanding of concepts (Fosnot, 1996; Gordon, 2009). Through the comprehension of key concepts, information will be accumulated and knowledge will be created (Gordon, 2009). The richness of learning coupled with conceptual understanding enables the learner to transfer those understandings to new and novel situations (Gordon, 2009). Through this, learners will have established the ability to problem solve.

* Cognitive Constructivism

Cognitive constructivism is concerned with the individual and the meaning they ascribe to the content they are learning, as well as how they create understanding (Cobb, 1996; Piaget, 1969; Powell & Kalina, 2009). Cognitive constructivism focuses on the methods that the learner uses to understand new concepts. It refers to how the learner comes to understand new concepts in their own mind. Cognitive constructivism is the individual process where the learner organizes, classifies, and associates incoming information with knowledge already created. It is a mental process of manipulating information until the learner understands the concept she is working with. Through the comprehension of key concepts, information will be accumulated and knowledge will be created.

In order for a student to learn a subject or discipline or concept with understanding, the individual must think about the topic under study and make sense of the information (Gordon, 2009; Powell & Kalina, 2009). Powell and Kalina (2009) stated, “if they [students] think critically, they will walk away with personal meaning that was constructed on their own” (p.45). When learners engage in the critical thinking
process they are making associations, classifications, organizations, etc. whereby constructing knowledge (Fosnot, 1996). Learning cannot be a passive activity because information is not absorbed (Liu & Matthews, 2005; Powell & Kalina, 2009).

Constructivists believe that learning is not transmitted from the teacher to the learner (Liu & Matthews, 2005; von Glasersfeld, 1996). Rather, learning takes place within the individual through their personal construction. Knowledge must be individually constructed to meet the needs of the learner whereby making constructivism “adaptive” (von Glasersfeld, 1996, p.3). Gordon (2009) noted that, “learners actively create, interpret, and reorganize knowledge in individual ways” (p.39). Since all learning in constructivism is personal and individualized, learners will progress at their own pace (Powell & Kalina, 2009).

Piaget’s (1969) theory of cognitive development declared that learning must be an active process in which the individual engages in thought and creates their own meaning related to the topic. With such emphasis on the individual and their ability to learn, cognitive constructivism is grounded in a humanist philosophy. When teaching through a cognitive constructivist framework it is important to consider the individual and their learning needs due to the attention on the individual learner.

A cognitive constructivist theory of learning complements a flipped classroom well. All new information is first presented via video lectures outside of class which allows the students to watch the lectures at their pace, not that of the teacher or class. This model of learning encourages students to begin thinking about the ideas on their own. Essentially, the video lectures ignite the cognitive constructivist process as the delay between the video and class time allows processing time prior to application. If
students engage with the lectures they will embark on the organization, application, and association processes central to cognitive constructivism. This theory of learning assumes though, that students will engage in the video lectures and think about mathematical ideas and concepts and make sense of the information.

**Social Constructivism**

In contrast to cognitive constructivism, social constructivism argues that learning occurs through participation in a social environment with other students and the teacher (Cobb, 1996; Liu & Matthews, 2005; Powell & Kalina, 2009). The social interaction assumes that communication and interaction occur and that both of those contribute to the learner’s ability to construct knowledge. According to Vygotsky (1962), communication and language use was a vital part of the learning process as students can learn from working collaboratively. Powell and Kalina (2009) asserted that, “teachers and students must communicate to convey information and for learning to take place” (p.247). While engaged in communication, the individual is continually working to incorporate the ideas and make sense of them as well as convince others of their point of view. Additionally, articulation is an active process of knowledge construction because it demands that the learner think critically about the content and organize the information so it can be presented to others (Powell & Kalina, 2009).

Social interaction is an important component of learning because it encourages the exchange of ideas and engages students in the act of thinking critically (Powell & Kalina, 2009) and that leads to personal meaning making. It exposes the learners to as many viewpoints as there are people in the group. The different perspectives assist in the creation of knowledge and understanding as the various perspectives were created from
the varied experiences of the individuals involved. The plethora of personal meanings offers numerous ways to think about and organize the topic of study in their own mind which enables other students to learn within a social context. How a learner makes sense of a concept may not make sense to anyone else, even the teacher, but may make perfect sense to that particular student.

Vygotsky (1962) theorized about a Zone of Proximal Development (ZPD) which is the realm where the student creates knowledge and understanding regarding the topic. In Vygotsky’s ZPD it is vital to understand that students need support to create knowledge in their zone and that all learning must be at the developmental level of the learner. Scaffolding is the process of supporting learners within the environment. As a result knowledge is created by building on each new layer of understanding. The dynamics of the developed community of practice from fellow classmates and teachers supports students and scaffolds learning (Powell & Kalina, 2009). As new understandings are created in the mind of the learner, the individual’s ZPD becomes larger (Vygotsky, 1962).

The flipped classroom supports a social constructivist view of learning. Since students will have already engaged in the video lectures outside of class and commenced the cognitive constructivist process, students arrive in class ready to engage in in-class activities and share their constructed ideas with others. The in-class portion of the flipped classroom is intended to be a dynamic, collaborative environment where students present and share constructed ideas and receive feedback from their peers and teacher. The social interactions will influence students’ learning so adjustments can be made to students thinking. The collaboration requires students to articulate their thoughts and fine
tune their constructed understanding. The social constructivist aspect assumes students will participate and engage in the collaborative environment. Due to its dependency on the context to students and ideas, the social constructivist perspective is context specific. Therefore, the ideas and knowledge construction cannot be duplicated exactly into another environment.

Assumptions of Constructivism

Constructivism is a theory of learning that can be integrated into developmental mathematics. In fact, national mathematical associations such as the National Council of Teachers of Mathematics (NCTM) and the American Mathematical Association of Two-Year Colleges (AMATYC) endorse constructivist classrooms (AMATYC, 1995; NCTM, 2000). However, before implementing a constructivist classroom, it is essential to understand some of the assumptions and challenges of this theory of learning. A concept pivotal to constructivism that differs from other theories of learning is that there is no absolute truth or ultimate way of knowing when constructing knowledge. Since there is no absolute truth (as dictated by those in positions of power) in constructivism, all knowledge created by the learner is validated to be true to them (Hyslop-Margison & Strobel, 2008). Constructivism builds knowledge from the learners’ perception and previous personal experience which are varied and dependent upon each learner’s ontological assumptions (Fosnot, 1996; Hyslop-Margison & Strobel, 2008; Patton, 2002; von Glasersfeld, 1996). As a result, each learner’s knowledge constructed for a concept can be as different as their fingerprints.

As students work to construct knowledge, they are also actively forming an understanding of the concepts. When understanding is acquired regarding mathematical
concepts, the learner can adapt that understanding in situations that differ from the context in which the knowledge was constructed. In other words, the learning can be applied to unique situations. Since constructivism is dependent upon personal experience and understanding, the knowledge created will be easier to extricate when needed as opposed to memorized information stored in isolation (Powell & Kalina, 2009).

When the focus is on learning procedures and skills as opposed to understanding the concepts, the learner is unable to apply those procedures in problem solving situations (Carpenter & Lehrer, 1999). Carpenter and Lehrer (1999) stated, “unless students learn with understanding, whatever knowledge they acquire is likely to be of little use to them outside the school” (p.20). Since the learner memorized the mathematics in a particular situation, students are unable to determine mathematical usage in a new situation. Learning mathematics for understanding will take time and that students may be resistant (Romberg & Kaput, 1999).

**Implications for Teachers**

Although teachers are no longer the center stage in constructivist classrooms, their role is pivotal to the success of the classroom. Educators must have an awareness of the student’s prior knowledge as that is where the learning begins in constructivism (Powell & Kalina, 2009); in their Zone of Proximal Development (Vygotsky, 1962). Learning tasks should be designed to begin in the students’ ZPD and work towards increasing each student’s zone through active learning strategies. Instruction should be challenging and aimed towards the learner’s higher end of the ZPD (Vygotsky, 1962). von Glasersfeld (1996) notes that, “the task of the educator is not to dispense knowledge but to provide students with opportunities and incentives to build it up” (p.7).
Constructivism demands that educators continually monitor their classroom environment with an awareness of the impact of the various teaching-learning strategies. Fennema, Sowder, and Carpenter (1999) encourage teachers to engage in the same mathematical situations as the students and work collaboratively to address the needs of the situation in an effort to create an awareness of what students would be doing and thinking as well as any problems or difficulties that may arise. Constructivist educators should be perceptive and work to understand how each pedagogical choice affects student learning and they must be flexible enough to make changes that will influence better teaching and learning.

Educators should ask questions that help them to understand their students’ mathematical thinking and to encourage concept development (Lester 1996). As educators participating in the constructivist environment we should not ask questions we can answer ourselves. Good questions will require students to justify their thinking which will in turn allow their constructions of mathematical knowledge to be examined (by both teachers and students) for discrepancies in understanding (Gordon, 2009; Hyslop-Margison & Strobel, 2008). It is imperative that the mathematical knowledge that students are creating is evaluated for mathematical accuracy as the learners can create knowledge that is mathematically incorrect.

Community of Mathematical Inquiry

A community of mathematical inquiry (CMI) is a model of learning that encourages dialogue and discussion among students (Goos, 2004). Knowledge is constructed in this model via the sharing of ideas and synthesizing of each other’s ideas into one formulation (Kennedy, 2009). The sharing of ideas and further evaluation of
those ideas leads to relevant mathematical thinking (Kennedy, 2009). It is at those moments when synthesis and analysis is occurring, engaging the learner in construction of knowledge. A CMI occurs within each student’s zone of proximal development and students are scaffolding each other’s learning through dialogue (Kennedy, 2009). Dialogue and discussion is central to this model of learning. A CMI assumes that when students verbalize their ideas and questions that it is helping them build knowledge and create understanding.

Under this framework, students engaged in mathematical discussions are, “questioning, offering examples, and counter-examples, asking for justification, giving reasons, offering clarifications, making propositional statements, exploring alternative positions and hypotheses, drawing conclusions, reasoning syllogistically, making inferences, and many others” (Kennedy, 2009, p.73). Differing ideas and the resolution of those different ideas is an important component of a CMI. The perfect CMI is one that is argumentative (Kennedy, 2009). The process of arguing naturally engages students in assimilating various ideas scaffolded by their peers. A CMI encourages mathematical reasoning and thinking while simultaneously transforming perceptions regarding mathematics (Kennedy, 2009). The focus of learning is not on memorization of procedures but rather understanding of mathematical concepts.

A teacher in a CMI is more of a facilitator rather than a teacher in the traditional sense. According to Kennedy (2009), a teacher is “to encourage the scaffolding process without providing direct answers or authoritative perspectives” (p. 75). A teacher in this environment would pose new thought provoking questions that might encourage students to find their own answers or demonstrate a different perspective to be considered.
Teachers using a CMI should expect varied perspectives and explanations and should not force students to accept a limited view of any concept (Kennedy, 2009). Teachers should teach the students to question, analyze, and argue as a tool to learning mathematics (Hunter, 2010).

Creating a CMI is a daunting task for educators (Hunter, 2010; Kennedy, 2009). Most educators need to change their perception of the classroom and the roles of both the teachers and the students (Hunter, 2010). Teachers wishing to change to this model of teaching and learning may encounter resistance from students, parents, and other constituents as this model is in opposition to the perception of mathematics teaching and learning (Hunter, 2010). Educators have the challenge of acclimating students to a more democratic, discourse oriented classroom (Kennedy, 2009). Teachers that want to begin to transition into a CMI should model mathematical thinking, problem solving, and enthusiasm for mathematics (Goos, 2004).

The teacher is not necessarily the only person that can foster learning in a CMI. The ideal CMI classroom shifts into a classroom where all perspectives are valued and each student is a component in the learning process. Students need to begin to see themselves and each other as learning tools and they will learn to engage in mathematical discourse through their teacher (Kennedy, 2009). Students in both Goos’ (2004) and Hunter’s (2010) studies became comfortable asking the person next to them for assistance or to ensure their thinking was correct. One student in Goos’ study commented, “so many times I find myself trying to explain something to other people, and you find something you’ve kind of missed yourself. . . Even if they don’t really know what they’re doing, explaining it to them imprints it to your mind” (p. 272). Hunter found that the
students changed in how they interacted with each other, the teacher, and their view of mathematics. Students became comfortable enough that they did not feel the need to involve the teacher in the discussion (Goos, 2004). Students began to take ownership and increase their responsibility in their learning and felt that explaining and justifying their ideas helped them to understand mathematics (Goos, 2004). Over time, Hunter found that “they [students] repositioned themselves in the community and assumed different roles and responsibilities” (p. 406). Students were scaffolding the learning for struggling students (Goos, 2004). Rather than simply supplying the struggling student with the answer, the stronger student continued to ask questions to help the struggling learner to find the answer on their own (Goos, 2004). Students felt that this math class was interesting and they enjoyed it because it revolved around understanding as opposed to memorization (Goos, 2004).

Developmental Education

This section begins with background information to help make sense of developmental education. Types of programs and components of developmental education are introduced next. The critical need for developmental education is after that, followed by a discussion around a theoretical framework for developmental education and directions for the future.

*Making Sense of Developmental Education*

According to the National Association for Developmental Education (NADE) developmental education “helps. . . underprepared students prepare, prepared students advance, advanced students excel” ([http://www.nade.net/aboutnade.html](http://www.nade.net/aboutnade.html), ¶ 4). Developmental education focuses on the whole student (Wambach & Brothen, 2000) and
respects the affective, cognitive, and financial aspects of a student’s life (Higbee, Arendale, & Lundell, 2005). It takes on many forms, although, it is best known for remediating students. However, it is also concerned with helping students persist to graduation (Burley, Butner, & Cejda, 2001). There has never been an educational system that has not needed developmental education services because there have always been students not prepared to enter higher education and institutions have admitted students that were below their usual admittance standards (Casazza, 1999). Fike and Fike (2007) stated that, “when an institution admits a student, it accepts the responsibility to do everything it can to help that student succeed. . . this responsibility demands that colleges and universities embrace remedial or developmental education as part of their mission” (p.2). The purpose of developmental education is to remediate students so they are prepared to enter college level courses (Waycaster, 2001). It is intended that at the end of developmental education coursework, one would not be able to differentiate between students who utilized developmental education services and those students entering college prepared for college level work. Participation in a developmental education program retains students and supports them in their pursuit of a degree (Penny & White, 1998).

Developmental education is an umbrella of services provided to enable students to thrive in higher education. Casazza (1999) noted that, “a developmental education approach is a comprehensive process focusing on the intellectual, social, and emotional growth and development of all learners” (p.4). In an interview, David Arendale noted that developmental education should be re-invented to change perceptions from remediation into learning assistance which helps all students succeed (Damashek, 1999b)
whereby becoming a resource on campus. Supporting Arendale’s comments, Boylan stated in an interview that attrition cannot be attributed solely to not being prepared for college level work but to a host of other reasons such as self-doubt, lack of study habits, familial distractions, lack of perseverance, etc. (Damashek, 1999a).

Developmental education programs are vital to students as the services it provides grants underprepared students the opportunity to gain access to higher education (Smittle, 2003). A conference chair conveyed the following thoughts to Casazza (1999) regarding the function of developmental education, “absolutely nobody – not one single person – should feel sentenced to a lifetime of exile from the world of learning. It is a matter of human dignity, in fact, a matter of real democracy” (p.2). In order to promote developmental education and create a successful program, developmental education needs to be valued as part of the institution (Boylan, 1999). Gerlaugh et al. (2007) commented, “when colleges offer developmental programs, they are saying they realize the value of creating opportunity for all citizens” (p. 3).

Developmental education is much more than simply reading, writing, and mathematics courses (Higbee et al., 2005). Hunter Boylan, director of the National Center for Developmental Education noted, “developmental education helps them become stronger students. Developmental education helps them better use of their talents. Developmental education gives them the opportunity to be successful” (Boylan, 1999, p.4). It encompasses an array of fields including but not limited to: remediation coursework, learning support, assessment and placement, and diversity (Lundell & Collins, 1999). Developmental education “must move from being viewed as a
‘remediation’ service to being an integral part of the student retention effort and as a
teaching/learning resource for the entire campus community” (Damashek, 1999a, p.20).

The goal of developmental education is to support and assist students who are not
adequately prepared for college as they work towards their pursuit of a degree (Boylan,
1999). Developmental education is crucial to our society; it enables those learners that
are underprepared and educationally marginalized access to higher education and creates
a more democratic society. Developmental students pursue higher education because
education is valued in our society and represents opportunities for a better life not only
for themselves but also for their families (Boylan, 1999). It is imperative then, that
developmental programs are incorporated and supported at all institutions.

Types of Programs

Developmental education has secured its own department at some institutions, is
included in the academic departments of others, and is not recognized at other
institutions. There are three types of developmental programs: centralized, de-
centralized, and learning assistance centers (Boylan, 1999). Centralized programs of
developmental education house all resources in one department to support and coordinate
services, with each component reporting to a common director (Boylan, 1999; Gerlaugh,
Thompson, Boylan, & Davis, 2007). Developmental educators in centralized programs
felt that services and learning support could be better coordinated than de-centralized
programs and serve the needs of the students better (Gerlaugh et al., 2007).

De-centralized programs are housed in their respective departments
(developmental math in the mathematics department, developmental writing in the
English department, etc.) and report to their individual departments (Boylan, 1999;
Gerlaugh et al., 2007). Services are generally not coordinated and there is no common director that all components report to (Gerlaugh et al., 2007). Educators in de-centralized programs felt that housing the developmental coursework in the respective department enabled a smooth transition into college level coursework (Gerlaugh et al., 2007).

Universities that are more research focused tend to exchange developmental courses and programs for learning assistance centers (Boylan, 1999). Learning assistance centers generally lack the developmental coursework and focus more on supportive aspects of developmental education such as: study skills, tutoring, academic advising, and counseling (Boylan, 1999).

Regardless of the type of developmental program, there are two models of developmental education and most programs can be classified as one or the other: prerequisite acquisition or concurrent acquisition (Higbee et al., 2005). In the prerequisite acquisition model students must take all necessary developmental courses before receiving permission to enroll in college level courses. Programs following a concurrent acquisition model allow students to enroll in developmental and college level courses simultaneously as long as the developmental coursework is not required for the college level course. For instance, students requiring developmental mathematics courses may not enroll in College Algebra but could take a course like Introduction to Criminal Justice.

Components of Developmental Education

Developmental services are typically thought of as the courses that are taught for remediation purposes such as reading, writing, and mathematics. However, developmental education meets numerous other student needs such as tutoring,
counseling, advisement, and other learning assistance services (Casazza, 1999; Duranczyk, 2007). Lundell and Collins (1999) also included assessment and placement, critical thinking, and diversity in their analysis of the literature regarding components of developmental education. A different literature review evaluated six components of developmental education: centralized developmental program, mandatory assessment of students, mandatory placement of students, tutor training, advising and/or counseling services, and program evaluation (Boylan et al., 1997). They found that each of the components they evaluated contributes to the success of developmental students. The program components in their study that had the most significant impact upon student success were centralized developmental programs, tutor training, and program evaluation.

Even though research demonstrates that centralized developmental programs (all resources housed together with a common director) are more effective and successful, more than half (56%) of developmental programs continue to be decentralized (Gerlaugh et al., 2007). In addition to developmental coursework, tutoring was present at 89% of institutions, academic advising at 78%, study skills workshops at 64%, freshmen seminar at 60%, and supplemental instruction at 25% of institutions (Gerlaugh et al., 2007).

Demonstrating the ubiquitous nature of developmental education, developmental reading, writing, and mathematics courses exist at 60% of private institutions (including non-profit, for-profit, 4-year, and 2-year) and 90% of public institutions (including 4-year and 2-year) (Snyder & Dillow, 2013).

Students at most institutions are usually filtered into developmental education through various assessments. The first assessment to determine a student's need for developmental services are usually Scholastic Aptitude Test (SAT) or ACT scores
due to the reading, writing, and mathematics components of the exams as well as the accessible nature of these scores. Students scoring below a specified cutoff score are then administered a college placement test like Accuplacer or COMPASS to further evaluate the student’s reading, writing, and mathematics ability and determine which developmental course(s) will best suit the student’s needs (Fine, Duggan, & Braddy, 2009). Both Compass and Accuplacer are computer adaptive tests developed by assessment companies, American College Testing (ACT) and College Board, respectively, to efficiently assess each student’s abilities and determine the appropriate course placement. Again, scores are compared to predetermined cutoff scores. The assessment data collected from students is to determine whether and what type of developmental coursework is needed. Developmental education claims to address the whole student, but there is limited to no evidence of institutions seeking out noncognitive information. Only seven percent of institutions used a noncognitive assessment with their students (Gerlaugh et al., 2007) to determine needed services.

**Critical Need for Developmental Education**

Although students are graduating from high school, one-third of those students are not academically prepared to successfully navigate college level coursework as well as balance the demands of college (Boylan, 1999). More than 34% of first-year undergraduates took a developmental course in 2003-04 (Snyder & Dillow, 2013). Of those students, 15% required mathematics, 6% reading, and 7% writing.

Even though some students are not prepared for college level work, that does not imply that the student does not have the ability to be successful in college, simply that the
student will require assistance in preparing for the level of work expected (Boylan, 1999). According to Burley et al. (2001), “placement into remediation will not ensure academic success, and it does not mean that students cannot do college credit coursework” (p. 779). Without developmental education programs and support, those individuals seeking opportunity, with the desire to earn a degree, but lacking the necessary skills would remain marginalized and disadvantaged (Boylan, 1999). All learners, regardless of ability and level of preparedness, may find themselves needing developmental services (Casazza, 1999).

Burley et al. (2001) asserted that many “developmental students regarded the college environment as hostile and unfriendly” (p.770). A large portion of developmental students are not successful in the developmental coursework and therefore do not have the opportunity to enroll in courses that count towards graduation requirements (Burley et al., 2001). That study also concluded that students in need of remediation dropout of college at a much higher rate than students not requiring remediation.

Of all the developmental students nationwide two-thirds of them attend a 2-year school while the other one-third will attend a 4-year institution (Boylan, 1999). Boylan (1999) went on to clarify the demographics of developmental students: the majority are Caucasian (Is that because they have more access to higher education?); less than one-third are minority students; African-American followed by Hispanic students are the majority of the minority; more than half the students are female; more than three-quarters are citizens of the US; 20% of the students are married; 40% receive financial aid; 10% of students are veterans; 33% work more than 35 hours a week; and 60% are young adults.
Students who have a successful developmental experience are more likely to persist and experience success in subsequent courses and are more likely to earn a degree (Penny & White, 1998). The most successful students are enrolled full-time (Bailey, Jeong, & Cho, 2010; Penny & White, 1998) and are taught by full-time female instructors (Duranczyk, 2007). African-American and Hispanic students are the most unsuccessful students (Bailey et al., 2010; Duranczyk, 2007; Penny & White, 1998) whereas Caucasian and Asian students are the most successful (Penny & White, 1998). Fike and Fike (2007) found that female students outperform male students and older students outperform younger students whereas Bailey, Jeong, and Cho (2010) found the opposite. Older students usually require more remediation than those directly out of high school and the severity of their deficiencies increased (Burley et al., 2001).

Students requiring the most developmental courses were more likely enrolled in large, urban institutions that were certificate oriented as opposed to degree granting institutions and served a large number of minority students (Bailey et al., 2010). The more learning deficiencies (of any student) the more likely the student has a lower GPA and/or drops out of school (Burley et al., 2001). To encourage success and enable retention, developmental students should have the opportunity to enroll in credit courses unrelated to the deficiency(ies) (Burley et al., 2001).

The research in developmental education is thorough as it illuminates student demographics and descriptive data about adult developmental learners. There is also ample evidence of programmatic components and their success in developmental education. The research does not explain why certain demographic groups are more successful than others and it does not provide strategies educators can utilize within their
classrooms to help students to be successful. It lacks prescriptive, pragmatic elements that educators can incorporate into their classrooms that will reduce the percentages above. Literature is needed that will influence the teaching and learning for adult developmental learners.

**Theoretical Framework for Developmental Education**

A theoretical framework “is the underlying structure, orientation, and viewpoint” of a study (Merriam & Simpson, 2000, p. 23-24). A theoretical framework provides a lens to help understand the phenomenon being studied through highlighting assumptions, guiding research questions, and assisting the researcher in interpreting the results.

A search of the literature for developmental education results in an abundant amount of research and conceptual ideas regarding this field of study. However, developmental education lacks a theoretical foundation on which to define itself and that unifies and informs practice (Chung, 2005; Lundell & Collins, 1999). Chung (2005) and Lundell and Collins (1999) noted that each component of developmental education uses theoretical frameworks specific to that discipline. Many of the theoretical frameworks utilized come from psychology (Lundell & Collins, 1999) and learning theories (Casazza, 1999).

There is a need for a theoretical framework to provide guidance and professionalize the field (Chung, 2005). Developmental education is continually justifying its place in higher education and fighting legislation against its removal. There is no common framework to bring coherence to the field and connect the components of developmental education under one umbrella (Lundell & Collins, 1999). Currently, each component of developmental education operates with borrowed frameworks and in
isolation from the other components that together create this encompassing discipline. A theoretical framework guiding developmental education would improve the quality of the field and inform the practice (Casazza, 1998). Developmental education is continually re-inventing itself through new definitions of the students it serves and re-examining curriculum because there is no common framework to bring everything together. A theoretical framework would help support the field and enable practitioners to make informed decisions (Lundell & Collins, 1999).

Teaching developmental mathematics is not the same as teaching math in the secondary schools and/or college level math courses. Developmental education has its own problems, issues, realities, and assumptions that are unique to the demographic and population of students it is serving. A theoretical framework targeted specifically for developmental education or developmental mathematics would be helpful and inform our understanding of phenomenon’s that are experienced.

Chung (2005) asserted that practice should drive and support a theoretical framework for developmental education. He stated that developmental educators are essential to theory development as their practical knowledge is an invaluable resource. Chung encourages developmental educators to reflect on their practice through reflective journals as a way to begin a draft of a theory. Chung cautions that the focus should not be on what works, but to detail why the method works, what you were trying to accomplish, and what assumptions go along with it.

**Directions for the Future**

Post-secondary institutions have much freedom regarding developmental education as each institution creates and monitors their own developmental courses
Institutions decide how many developmental courses they will have as well as the curriculum for each course and whether students need a C or better to go on to college level courses or to simply pass the developmental course with a D (Waycaster, 2001). Since institutions have the freedom to define, create, and manage their own developmental courses, developmental mathematics varies across institutions.

Duranczyk and Higbee (2006) noted the lack of consistency between developmental programs and courses in post-secondary institutions as well as the lack of consistency between mathematics offerings and requirements in high schools across the nation. There is not a standardization of developmental mathematics across states and “few states have exit standards for remedial courses” (Waycaster, 2001, p. 405).

Due to the wide array of services offered, developmental education serves a diverse population and represents the most at-risk population in higher education. As such, developmental students require more support than non-developmental students. Duranczyk and Higbee (2006) noted that, “developmental education students from nontraditional, underprepared, and underrepresented populations do not mirror traditional college students’ behaviors or needs” (Duranczyk & Higbee, 2006, p.23). Developmental students struggle with monitoring their own learning, their progress within their program, and tend to rely heavily on their instructors for support. They do not possess a high level of motivation and have weak study skills (Higbee & Thomas, 1999). As a result, developmental educators must lead and instruct the students more than their academically prepared counterparts (Smittle, 2003) and are usually more student oriented versus non-developmenta...
and programs and become more dependent upon themselves and intrinsic motivation (Wambach & Brothen, 2000).

Much of the research and literature on developmental education focuses on pass rates of developmental and subsequent courses (Gerlaugh et al., 2007), rates of retention (Bailey et al., 2010; Gerlaugh et al., 2007), student demographics (Bailey et al., 2010; Boylan, 1999), program components (Boylan et al., 1997; Gerlaugh et al., 2007), traditional age students (Miglietti & Strange, 1998), and examination of theoretical frameworks as relevant to developmental education (Chung, 2005; Higbee et al., 2005; Lundell & Collins, 1999; Wambach & Brothen, 2000). Although developmental education serves a large adult population, the literature only includes a cursory overview of adult students (Lundell & Collins, 1999). Developmental education also claims to address diversity in the classroom but in reality does not embrace it as the majority of research focuses on programmatic elements (components, centralized versus decentralized, assessment and placement, etc.) or success rates of students in each of the disciplines (reading, writing, and mathematics) and does not address why some demographic groups outperform others. Much of the research is focused on traditional age, non-minority students even though the population served through developmental education is very different from what is studied.

There are very few qualitative studies related to developmental education. Qualitative studies would enable researchers to understand the meaning of developmental education from the perspective of those individuals actively involved within the discipline. What is the experience like for developmental students? What can we learn from students that will inform practice? Higbee et al. (2005) noted the need for research
to focus on student voices, and called for interviews, surveys, case studies, focus groups, and longitudinal studies, “listening to student voices can strengthen the work of developmental educators” (p. 9). There is also a need for research that focuses on what educators do in their classrooms to encourage success without losing valuable academic outcomes (Higbee et al., 2005). Studying the effects of a constructivist, flipped classroom may begin to address this concern.

Developmental Mathematics

This section discusses the literature related to developmental mathematics. Background information is provided to create an understanding of developmental mathematics, followed by a review of the research centered on the key themes: faculty/instructor characteristics, student characteristics, effective classroom practices, and program components.

Understanding Developmental Mathematics

Developmental mathematics courses are intended for students who are not prepared to enter college level mathematics courses, such as College Algebra or Introduction to Statistics. These courses are designed to remediate students so that they may pursue their career and life goals. Developmental courses at my institution do not count for graduation credit; they do not fulfill general education or major requirements. The courses do, however, get factored in the student’s GPA.

There is a lack of consistency between developmental programs and courses in post-secondary institutions as well as the lack of consistency between mathematics offerings and requirements in high schools across the nation (Duranczyk & Higbee,
Students could potentially complete Intermediate Algebra at one institution with a grade of D and go on to college level math courses while other institutions require a grade of C or better to advance to college level math courses. In addition, Intermediate Algebra may be the final developmental course prior to College Algebra at some institutions while others will sequence another developmental math course after Intermediate Algebra or count Intermediate Algebra as a credit bearing math course.

Developmental mathematics students represent an at-risk population of learners. Since students are less prepared in mathematics than any other subject (Fike & Fike, 2007) mathematics is “the most difficult area to remediate” (Burley et al., 2001, p.778). More students require developmental mathematics than developmental reading or writing (Penny & White, 1998). Due to the challenges, developmental mathematics often keeps students from persisting to graduation (Duranczyk, 2007) and only half of the students who enroll in developmental mathematics complete it successfully (Burley, Butner, & Cejda, 2001). It was noted that:

- many students see mathematics as a required but unpleasant subject. They perceive mathematics as isolated, having no relationship to life, no relationship to future career needs, and no connections to other college courses. Student attitudes and beliefs in mathematics quite often block the knowledge that we as instructors want them to obtain. Coming from a background of memorized algorithms and frustrating mathematics course experiences, students often bring an attitude of defeat with them to the first day of class. (Collins & Winnington, 2010, p. 42)
Mathematics is the deficiency that is most influential in determining the successful completion of the degree program (Fike & Fike, 2007).

This weakness of math among some college students warrants a need for developmental education in post-secondary institutions. Burley et al. (2001) noted, “85% of first-time-in-college freshmen were diagnosed as needing remediation, particularly in mathematics” (p. 768). Just as alarming, a study completed on 63,770 students attending community colleges in Texas found 2% of the students needed remediation in reading, 4% in writing, and 17% in mathematics. The previous statistics refer to the students with only one area of need. The study also concluded that 26% of the total population had deficiencies in all three areas (Burley et al., 2001). Half of the students entering community colleges in Texas are deficient in at least one area with a quarter of them deficient in all three.

Regardless of the courses offered or policies regarding developmental courses, the institution must commit to and support the developmental program (Duranczyk, 2007). As part of that commitment, it is seen as necessary for institutions to have appropriate support programs (Armington, 2002; Boylan, 2002; Duranczyk, 2007) such as counseling, advising, tutoring, etc. to support the coursework as adult developmental learners have unique needs. Students felt since “the university accepted them for enrollment, then the university had a responsibility of providing all the services they needed to be successful which included developmental mathematics” (Duranczyk, 2008b, p. 51).

If developmental education were only accessible in the community college and not 4-year universities, those that are educationally marginalized would not have access
to a 4-year degree (Duranczyk & Higbee, 2006). Students who enroll in a community college are not as likely to transfer and persist to a bachelor’s degree as those students who enroll directly in a university (Duranczyk & Higbee, 2006). Students in Duranczyk’s (2008b) study stated the need for developmental mathematics at 4-year institutions. If developmental mathematics was not offered at universities then many students would not seek out a bachelor’s degree because they would not endure the hassle of enrolling in two different institutions: one for developmental courses and one for general education and degree classes. Therefore, there is a need to offer developmental coursework at the university level to support those students that are marginalized in earning a bachelor’s degree and it greatly increases the opportunities available to students. Developmental education programs are vital to many students as the services the program provides grants developmental students the opportunity to participate in higher education (Smittle, 2003) and it benefits society as it enables more citizens to attain a college degree. Without developmental education, students in need of remediation would not be able to earn a college degree. For these students lack of access to higher education leaves few options such as unemployment, minimum wage jobs, welfare, and incarceration (Waycaster, 2001).

Review of Research

The literature reviewed regarding developmental mathematics was varied. Of the more than 25 studies examined, they all researched four primary areas: course structure, technology use, pedagogical tools, and course and student success. Two studies examined courses that were structured as paired courses, developmental reading and developmental mathematics (Kirk & Lerma, 2010) and developmental mathematics and
college algebra (Vasquez Mireles, Offer, Ward, & Dochen, 2011). Two other studies altered the course structure by incorporating problem based learning (Goldstein, Burke, Getz, & Kennedy, 2011) and supplemental instruction (Wright, Wright, & Lamb, 2002).

Those studies that examined technology used treatment programs such as Assessment and LEarning in Knowledge Spaces (ALEKS) (Fine, Duggan, & Braddy, 2009), compared traditional classes to online and hybrid courses (Spradlin & Ackerman, 2010; Zavarella & Ignash, 2009), and examined student motivation and learning strategies in an online course (Wadsworth, Husman, Duggan, & Pennington, 2007).

The studies that researched pedagogical tools focused primarily on the incorporation of writing tasks (Ganguli, 1989; Ganguli, 1994; Grossman, Smith, & Miller, 1993; Harchelroad & Rheinheimer, 1993; Lesnak, 1993) and structured feedback with a focus on mastery learning (Yopp & Rehberger, 2009).

Numerous studies were interested in studying specific factors that affect student success (Duranczyk, 2008b; Higbee & Thomas, 1999; Penny & White, 1998; Waycaster, 2001; Wheland, Konet, & Butler, 2003). One study investigated the success of developmental mathematics students in college level math courses and what changes could be made to improve developmental mathematics programs (Parmer & Cutler, 2007). Li, Zelenka, Buonaguidi, Beckman, Casillas, Crouse et al. (2013) focused on appropriate and consistent course placement and the effort needed by students to succeed in the course. Dasinger (2013) worked to determine the ways in which adult students view their successes and failures with respect to mathematics while a different study examined how students shift from unsuccessful math students into successful students (Howard & Whitaker, 2011). Four studies (Duranczyk, 2008a; Duranczyk, 2008b;
Duranczyk & Higbee, 2006; Weinstein, 2004) examined the perspectives of students in relation to the role of developmental education at the institution and its service to the students. There are no studies to date that examine all four elements noted above, course structure, technology use, pedagogical tools, and course and student success. This action research study will attempt to fill that void as it will incorporate a different course structure within developmental mathematics, use technology through pre-recorded video lessons, rearrange the pedagogical norm through flipping the classroom, and look for signs of success with the flipped developmental classroom.

Examination of the literature associated with developmental mathematics, resulted in four primary themes: faculty/instructor characteristics, student characteristics, effective classroom practices, and program components.

Faculty/Instructor Characteristics

This section addresses characteristics of faculty that support students in developmental programs such as full-time versus part-time, faculty degrees, personal characteristics, and what faculty can do in the classroom to encourage success.

The challenges that developmental students face create formidable obstacles for them as well as the faculty. Research reveals that it is vitally important to employ developmental educators who are invested in working with underprepared students due to the specific challenges they present and faculty who are not motivated to do so should not be assigned to teach developmental courses (Smittle, 2003). Many universities and colleges should attempt to recruit developmental educators that have experience in teaching high school mathematics (Spradlin & Ackerman, 2010). Spradlin and Ackerman (2010) stated, “instructors must be committed to continually improving their
instructional practice in order to provide a high quality education for all students, no matter what method of instruction is being used” (p.18).

More than two-thirds of developmental mathematics faculty at 4-year institutions are part-time and 70% of them have five or fewer years of teaching experience (Penny & White, 1998). It was noted that part-time faculty hinder student success due to their lack of: accessibility, knowledge with course content and advisement, appropriate office space as well as lower expectations for students (Fike & Fike, 2007). Part-time instructors cannot and/or do not hold ample office hours (Fike & Fike, 2007) which students can utilize as an out of class resource. Full-time faculty are more familiar with the curriculum, what needs to be accomplished for success in subsequent coursework, and have an awareness of student needs and characteristics (Penny & White, 1998). Students with full-time developmental mathematics instructors tended to do better in college algebra versus those students who had part-time instructors (Galbraith & Jones, 2006; Penny & White, 1998).

Graduate degrees and advanced training in developmental education was also found to impact student success along with employment status (full- versus part-time). It was determined that faculty who held a graduate degree promoted more success with students (Fike & Fike, 2007) but developmental mathematics instructors are more likely than other instructors to hold only a bachelor’s degree (Penny & White, 1998). Developmental mathematics faculty have degrees in mathematics, but the majority of faculty lack formal education regarding developmental education and teaching underprepared students (Duranczyk, 2007). As such, faculty should be supported to gain graduate degrees and participate in professional development opportunities (Duranczyk,
2007; Smittle, 2003) as they have a significant impact upon success. Educators trained in developmental education, such as the Kellogg Institute, which trains and certifies developmental educators at the National Center for Developmental Education, contributes to successful programs as well as the emerging doctoral programs in developmental education like those at Grambling State University and Texas State University. Faculty trained in developmental education are more apt to handle the challenges they will face.

In addition to graduate degrees and full-time employment, there are other aspects found to be important qualities for a developmental educator. Teaching any subject requires a certain level of intuition regarding the students, the teaching, and the learning environment (Galbraith & Jones, 2006). Developmental mathematics instructors simultaneously teach students mathematics and to dismantle their misconception that they cannot learn math (Galbraith & Jones, 2006). Individuals seeking a position in developmental education should have the ability to work with students from diverse backgrounds and needs and recognize the many affective issues that influence and distract students. Developmental educators need to also be flexible and offer various methods of instruction to help their diverse learners to be successful (Spradlin & Ackerman, 2010).

Besides carefully chosen classroom activities, faculty that demonstrated compassion, support, and encouragement positively affected student success in developmental mathematics and students benefitted from interacting with mathematics faculty who were interested in their success (Duranczyk, 2008a). Programs and instructors should focus on both academic and affective behaviors as they work towards
helping students achieve mathematical success (Li, Zelenka, Buonaguidi, Beckman, Casillas, Crouse, et al., 2013). It is imperative in developmental mathematics that an alliance is formed between the teacher and the students as well as between the students (Galbraith & Jones, 2006). One student stated, “I just needed a little extra help, and she was always willing to do that” (p.25). Another student commented, “I don’t feel that we were talked down to or belittled or, or judged for whatever reason we may have been in those classes” (p.25).

It takes a unique individual to teach developmental mathematics students and those students are more dependent upon the faculty than non-developmental students. Faculty need to transition from an instructor of developmental education to a facilitator and students need to work towards independence from instructors (Kinney, 2001). As a way to foster autonomy, students should monitor their own progress and grade throughout the semester (Kinney, 2001). One way to help students to monitor their own progress is for faculty to provide frequent and helpful feedback (Boylan, 2002; Kinney, 2001; Smittle, 2003). Wadsworth et al. (2007) noted that feedback is vitally important within the developmental classroom. Faculty can also journal with the students as a way to monitor their progress and understanding and to provide feedback (Duranczyk, 2008b).

**Student Characteristics**

This section discusses characteristics of developmental mathematics students. It begins with a description of the students, addresses student self-confidence, highlights student perspectives regarding developmental mathematics, and examines learning by memorization.

Students need developmental mathematics courses because they have forgotten what they were previously taught, never learned what they were taught (Kinney, 2001), and/or are not completing sufficient college preparatory mathematics courses in high
school (Burley et al., 2001). Up to 40% of incoming students at four-year institutions require some form of developmental education (Vasquez Mireles et al., 2011) and more than 40% of the students graduating from five different institutions had at least one developmental course in their college career (Waycaster, 2001).

More developmental students persisted to the second year of college than their non-developmental counterparts (Waycaster, 2001). Unfortunately, students enrolled in developmental mathematics are less likely to earn a degree and when compared to other developmental courses, are more likely to repeat developmental mathematics (Vasquez Mireles, et al., 2011). Students placing into developmental courses are likely to take longer to graduate as they are delayed in their mathematical course sequence (Dasinger, 2013). The more prepared students are in the beginning of the semester, the more knowledge they are able to acquire throughout the semester (Li et al., 2013). A student’s success in developmental mathematics directly affects their future aspirations (Spradlin & Ackerman, 2010).

The most successful developmental students are enrolled full-time (Penny & White, 1998) and are taught by full-time female instructors (Duranczyk, 2007). Adult students are more underprepared than those students directly out of high school (Burley et al., 2001). Female students outperform male students (Fike & Fike, 2007; Spradlin & Ackerman, 2010) and older students outperform younger students (Fike & Fike, 2007). Female students attributed their success/failure to internal factors (study habits, time, etc.) while male students attributed their success/failure to external factors like faculty, course, etc. (Dasinger, 2013). African-American and Hispanic students are the most unsuccessful students (Duranczyk, 2007; Penny & White, 1998) whereas Caucasian and
Asian students are the most successful developmental learners (Penny & White, 1998). Students with higher mathematical ability blame their failure on a lack of effort while lower performing students blame their failure on their lack of mathematical ability (Dasinger, 2013).

Unsuccessful developmental math students view class attendance and homework completion as useless and they are not motivated to study and learn mathematics (Howard & Whitaker, 2011). These students do not have any strategies to learn mathematics and practice avoidance behaviors such as not attending class, not completing homework, not seeking out additional assistance, and not participating in class (Howard & Whitaker, 2011). Vasquez Mireles et al. (2011) commented on changing student behaviors to help them be successful, “change can only occur once a student has recognized a need for change. This awareness is the first step, but taking action and making the change occur is the most challenging for students” (p.19). One student commented regarding their attitude toward learning math, “the difference in my attitude allowed me to get the negative thoughts out and become more interested. No matter what the class or problem, attitude determines your success” (Vasquez Mireles et al., 2011, p.18).

Successful students noted that their motivation is pivotal to their success (Howard & Whitaker, 2011). One student stated that, “my attitude toward math is totally opposite than it was in high school. I enjoy learning and knowing math now. I enjoy my math class” (p.8). Successful students believe they can learn mathematics if they invest the time and effort into learning it (Howard & Whitaker, 2011; Wadsworth, Husman, Duggan, & Pennington, 2007). Wadsworth et al. (2007) described successful students as,
“effective learners are those who have developed a wide array of reliable learning strategies and use them flexibly and efficiently” (p. 7). Since these students seat themselves to avoid distractions and maximize their ability to pay attention, they are usually seated near the front (Howard & Whitaker, 2011). They focus on understanding and routinely complete more homework than necessary to ensure they know what they are doing (Howard & Whitaker, 2011). Vasquez Mireles et al. (2011) found that students were able to improve their level of concentration, motivation, ability to learn, metacognition, test preparation strategies, time management, and learning new study strategies while Wadsworth et al (2007) found that a student’s score on the motivation, concentration, information processing, and self-testing strategy scales was predictive of their final grade in the course. Successful students noticed that learning mathematics is a time consuming task but they gain a sense of empowerment from their success which fuels the motivation to learn and aids in their success (Howard & Whitaker, 2011). One student commented, “math is a lot of work. You have to do your homework. You have to study. That’s the good thing about math. If you put in the work, they you will get the grade. If you don’t, you won’t. It’s as simple as that” (Howard & Whitaker, 2011, p.10).

A student’s self-confidence and belief about themselves was shown to affect their ability to learn and their level of success, especially in developmental mathematics (Duranczyk, 2007; Duranczyk, 2008a; Duranczyk & Higbee, 2006; Higbee & Thomas, 1999). Students commented that their confidence improved as a result of their positive experience with developmental mathematics (Duranczyk, 2008). One student stated, “gaining more self-confidence which I gained from the developmental mathematics program has had a very positive impact on my life” (Duranczyk & Higbee, 2006, p.26).
Students did not characterize the developmental courses negatively (Duranczyk & Higbee, 2006). Rather, the students felt as though the developmental courses gave them the opportunity to overcome obstacles. Students “discovered that mathematics no longer limited their options but could empower them. Developmental mathematics at the university opened that door” (Duranczyk & Higbee, 2006, p.28). The students would however, like more transition from the developmental coursework into college level courses (Duranczyk, 2008b).

Contrary to the students in Duranczyk and Higbee’s (2006) study that viewed developmental mathematics positively, students in Wheland, Konet, & Butler’s (2003) study viewed Intermediate Algebra as a refresher course and did not understand how the course would assist them in their college level math courses they would be required to take. Students felt they didn’t need to take the course seriously because it did not count for graduation credit and they claimed that they were doing well in all of their classes except Intermediate Algebra and blamed the course for their poor performance. Students targeted their lack of success to aspects that they could not control like lack of graduation credit, native language of instructor, etc. Unfortunately, student grades in Intermediate Algebra paralleled their semester GPA and those students who were struggling in Intermediate Algebra were also struggling in their other courses. Although those students did not understand the significance or value the course, it would seem that since those students struggled in all of their courses that the issue was not the developmental mathematics course but larger issues with the student such as study skills, acclimation to college environment, work ethic, etc. Underprepared students are not “a group of
students who [are] naturally motivated to study mathematics” (Seto & Meel, 2006, p. 213).

Research found that developmental mathematics students see mathematics as disconnected, meaningless rules and steps to follow (Stigler, Givvin, & Thompson, 2010). Students focus on obtaining an answer rather than attempting to understand what the question is asking them to do and they cannot interpret mathematical questions and their answers to the questions (Stigler et al., 2010). Students who scored higher on placement tests did not seem to understand mathematics better; they just remembered more mathematical procedures and were able to use them correctly (Stigler et al., 2010). Students are more interested in obtaining procedural fluency but instructors and tutors work to help students develop an understanding of underlying mathematical concepts (Weinstein, 2004). It was found that students only employ reasoning skills as a last resort after they have exhausted all their memorized procedures (Stigler et al., 2010).

Overall, students in general are not prepared for college level mathematics coursework and require developmental mathematics to help them meet graduation requirements. The research shows that adult students are more successful than traditional college students (Burley et al., 2001) and that minority students struggle in developmental mathematics (Duranczyk, 2007; Penny & White, 1998). Student self-confidence is lacking but a successful developmental mathematics experience increases their confidence and empowers them (Duranczyk, 2007; Duranczyk, 2008a; Duranczyk & Higbee, 2006; Higbee & Thomas, 1999). Although developmental mathematics has a negative stigma attached to it, it does help students prepare for college level work (Wheland et al., 2003).
The literature has told us that underprepared students are not naturally motivated learners. Howard and Whitaker (2011) found that students noticed learning math is a lot of work. We can create a demographic picture of who typically succeeds in developmental mathematics and who struggles, but how do you motivate the unmotivated student? How do you convince students to invest the effort in learning math? The research in developmental mathematics has also demonstrated that a student’s self-confidence is a contributing factor to their attitude and success. How do faculty assist in the development of a student’s self-confidence? Several studies noted that underprepared learners lack study skills and effective learning strategies. Are there certain strategies that are more effective than others? How do faculty teach study skills strategies in addition to the regular curriculum?

*Effective Classroom Practices*

The following section focuses on effective practices educators can implement into their classrooms to support adult developmental learners. The literature accentuates the importance of study skills, expectations of students as learners, conceptual teaching and learning, collaborative learning, and course structure.

Many students lack adequate study skills, note-taking abilities, and an understanding of post-secondary expectations. Therefore, developmental faculty must lead and instruct developmental students more than their academically prepared counterparts (Smittle, 2003). Vasquez Mireles, Offer, Ward, and Dochen (2011) stated that “in order to increase academic performance, study strategies need to be taught to students” (p.14). Another group of researchers strongly encourage faculty to teach study strategies for online courses they may be teaching (Wadsworth, Husman, Duggan, &
Pennington, 2007). Also, since students struggle with time management, research reveals that they be made aware of course expectations, due dates, etc. and be encouraged to utilize additional resources that support success (Galbraith & Jones, 2006; Kinney, 2001; Smittle, 2003). Students are more successful with faculty who establish clear expectations and due dates (Galbraith & Jones, 2006; Kinney, 2001; Smittle, 2003) and help students to monitor their own learning (Kinney, 2001). It is important for developmental educators to provide structure and to clearly articulate their expectations.

One study found that highly structured learning environments help support student success (Vasquez Mireles, Offer, Ward, & Dochen, 2011). One student in that study commented on the course structure, “This class helps students in all areas by guiding us w/lots of structure” (p.40). Developmental mathematics instructors can provide students with course assignments containing all due dates for the entire semester as a way to help students develop the skills necessary to manage their time and exceed expectations (Kinney, 2001). Beginning the course with all course expectations clearly articulated will help support the students towards success and self-regulation, a skill which will enable them to be successful beyond the developmental course(s) (Wambach & Brothen, 2000).

Research has shown that it is important to teach students to understand the concepts and ascribe meaning to them as opposed to learning meaningless bits of information scattered over the course of a semester (Galbraith & Jones, 2006; Spradlin & Ackerman, 2010). Successful learning occurs for developmental students when they have the opportunity to connect incoming information to knowledge that has already been created (Smittle, 2003). Teaching practices that focus solely on implementation of procedures and not on developing a conceptual understanding sets students up for failure
and further instills in them their inability to do mathematics (Stigler et al., 2010). Traditional classrooms employ fast-paced lectures which require students to absorb information at a breathtaking pace and work towards comprehension on their own outside of class. This type of environment tends to promote memorization, work in isolation, and procedural applications. Developmental students have difficulty understanding the content during lectures and when they work in isolation (Weinstein, 2004). Lecture style classes are not organized well for adult developmental students to consider, integrate, and think about course concepts.

Students need to become active learners in the classroom (Kinney, 2001) by asking questions, taking good notes, and engaging with the tasks (Howard & Whitaker, 2011). Developmental mathematics students need to work collaboratively and learn from each other (Higbee & Thomas, 1999; Kirk & Lerma, 2010) and as they do, they naturally reduce their math anxiety (Galbraith & Jones, 2006). Communication tasks such as speaking, listening, and writing facilitates constructivism in the classroom (Kinney, 2001) which provides students with the opportunity to engage with and consider the ideas being presented. Researchers advocate for developmental students to form social networks outside of class for the purpose of helping each other academically as well as providing support for each other (Higbee & Thomas, 1999; Kirk & Lerma, 2010).

Although educators would like for students to form study and support groups outside of class, it is important to mention that adult developmental students have a myriad of issues and responsibilities that detract time and attention away from those types of activities.

Developmental mathematics courses are structured in numerous ways based upon what works for the institution and the needs of the students. Some developmental
courses are lecture based while others have transitioned into computer assisted courses. One study of 15 developmental mathematics courses situated in a community college found that classroom instruction was dichotomous with either lecture methods or computer assisted instruction (Waycaster, 2001). Spradlin and Ackerman (2010) found in their comparison between a traditional developmental mathematics classroom and one supplemented with computer assisted instruction where students completed their homework using the textbook software that students learn just as well with or without the computer assisted instruction.

Kinney (2001) noted that developmental learners are more successful when they learn to monitor their own learning but how is that skill taught to the underprepared population? The research has also found that teaching for understanding is beneficial to student success but it does not list any strategies on how to accomplish teaching in that manner. Weinstein (2004) found that students struggle to understand lectures during class and when they work by themselves. Would the flipped classroom help to address this concern since students would have time to process the lecture before attempting to apply the ideas?

Program Components

This section will focus on facets of developmental mathematics that provide support to students such as: support and commitment from the institution, structure of developmental courses, and student support programs.

In order for developmental mathematics programs to be successful, the institution must commit to and support the developmental program (Boylan, 2002; Duranczyk, 2007). Numerous four-year institutions do not offer and/or support developmental
coursework. Underprepared students at those institutions must enroll in a community college in order to satisfy their developmental requirements. Taking developmental courses at a community college as opposed to a university discouraged students from pursuing a bachelor’s degree, further illustrated their perceived deficiencies, stigmatized them, and those students would not have pursued degrees with any kind of mathematics requirement (Duranczyk & Higbee, 2006). When asked about taking developmental mathematics at a community college rather than a university because the university does not support such coursework, students commented regarding their lack of self-esteem with respect to mathematics and the perceived barrier from the discipline. One student stated, “I probably wouldn’t have gone back to college. If I thought that my whole placement—my whole chance of getting into college was based on a math test, I probably would have said, ‘You know what? This isn’t for me.’” (Duranczyk & Higbee, 2006, p. 24). Another student commented, “That’s going to make me feel like I am the dummy. That’s going to make me feel more demoralized. That’s going to make me feel more like I can’t do it, like I’m different, like [sic] I’m lower” (Duranczyk & Higbee, 2006, p. 24).

Research has shown that developmental programs should focus on developing a sense of community (Duranczyk, 2007; Smittle, 2003) where students can feel as though they are not the only student dealing with deficiencies and draw strength from others who have succeeded. Students gain a sense of community from developmental courses and programs and the sense of community that develops helps them in their pursuits at the university (Duranczyk & Higbee, 2006). Helping students to feel like they belong in the program and the institution, aids in retention.
Assessment and LEarning in Knowledge Spaces (ALEKS), a computer adaptive mastery learning system, was utilized as an intervention at a community college to determine if students could be remediated prior to entering developmental mathematics (Fine, Duggan, & Braddy, 2009). Students worked for four hours each week in ALEKS during their scheduled class time. The professor did not lecture but rather circulated throughout the room and answered questions as students had them. The researchers found that ALEKS helped remediate students but it is not as helpful as taking a math class during the students’ senior year in high school.

Another study, also conducted at a community college, compared online, hybrid, and lecture courses (Zavarella & Ignash, 2009). They found that lecture based courses were better at retaining students than courses involving computers. Students enrolled in online learning environments face different distractions than students in traditional classrooms and do not have access to the same resources (Wadsworth et al., 2007). Perhaps students felt as though computer based courses would take less time and be easier to understand than lecture based classes (Zavarella & Ignash, 2009). Wadsworth et al., (2007) did not find any significant differences in their study in student’s study strategies and self-efficacy in online or traditional classrooms but they did find that female students were significantly more motivated than their male classmates. They do recommend that faculty should teach students the necessary learning strategies to be successful in an online environment (Wadsworth et al., 2007). Computer based courses also lacked contact with faculty and other students and in my experience, developmental students thrive on contact with faculty and the need to feel immersed in a community of practice.
At some institutions, mathematics is paired with reading courses, writing courses, or study skills courses. A study which paired developmental mathematics with reading found that students improved their mathematical skills over the course of the semester as determined by final course grades (Kirk & Lerma, 2010). Throughout the research, study skills were integrated within the course and modeled at appropriate times and students were required to attend two hours of math lab outside of class time. Although the percentage of students earning a grade of C or above in the paired sections was considerably higher than the traditional classes, I question the significance of that finding due to such low enrollment (8 students) as well as the additional supports (math lab and study skills) that were built into the course. Any one of the additional factors (or a combination of them) could have contributed to the success as well as the increase in collaboration during the class period or the ability of the instructor to have individual contact with all students during the study.

The literature addresses a variety of support programs and different ways to structure developmental mathematics. Most of the programs are successful in helping the students to achieve success in developmental mathematics. Much of the research observes the effects of a treatment (ALEKS, writing tasks, paired courses) on student success. Success of developmental education services is usually measured by the student’s success in the developmental course, subsequent college level courses, GPA, and graduation and retention rates (Duranczyk & Higbee, 2006). Additionally, those measures of success in higher education are typically focused on traditional age students who are prepared for college level work (Duranczyk & Higbee, 2006). None of the programs examined active learning or a flipped classroom.
A few articles (Galbraith & Jones, 2006; Grossman et al., 1993; Kinney, 2001; Stigler Givvin, & Thompson, 2010) mentioned the importance of understanding mathematical concepts but few tried to nurture the development of a conceptual understanding in the course. Parmer and Cutler (2007) administered surveys that asked students to focus on their understanding of course concepts and how difficult they found the material. Survey results illustrated that developmental students struggled more than non-developmental students in understanding course material and that developmental students found the content more difficult to understand. It is evident that developmental mathematics students experience difficulty in processing and understanding mathematics and require additional support.

The research frequently suggested that developmental mathematics students be immersed and engaged in a collaborative learning environment where they are learning from the instructor as well as each other (Galbraith & Jones, 2006; Harchelroad & Rheinheimer, 1993; Higbee & Thomas, 1999; Weinstein, 2004) While students are working in a collaborative environment, they are naturally engaging in discourse, whether through speaking, writing, and/or listening, and that discourse encourages knowledge construction (Grossman, Smith, & Miller, 1993; Kinney, 2001). Students are also receiving immediate feedback which was seen as essential for growth (Yopp & Rehberger, 2009). How do faculty encourage and maintain that type of environment? Are there particular techniques that support communicative, collaborative learning? How do faculty maintain that environment on a daily basis? Do students get discouraged or frustrated by that situation every day?
Since it has been shown that collaboration and discourse and articulation aids in learning mathematics, why not make that the focus of the classroom? A flipped classroom may be able to accomplish exactly that. The flipped classroom would move the lecture, which is a passive learning activity, to the periphery and prioritize the application and understanding of course content to valuable class time where students can work collaboratively to learn mathematics. At the same time, the flipped classroom would integrate time for students to analyze mathematical ideas with the help of their professor and classmates. Time would also be allotted for students to immerse themselves into the application of those mathematical ideas.

Flipped Classroom

In the sections that follow, the flipped classroom is defined and characteristics of the flipped classroom are provided. Next, findings are organized in conjunction with key themes from the literature. The literature review concludes with suggestions for implementing a flipped classroom and a discussion of the challenges and limitations of a flipped classroom.

Definition of a Flipped Classroom

A flipped or inverted classroom utilizes educational videos to provide preliminary instruction outside of class and transforms in-class time from listening to lectures into time for students to process the mathematical ideas and concepts in a supportive learning environment (Lage, Platt, & Treglia, 2000; McDaniel & Caverly, 2010; Tucker, 2012; Wentland, 2004). Homework and other extension activities are now reserved for in-class work where assistance can be sought either from classmates and/or instructors (Lage, Platt, & Treglia, 2000; McDaniel & Caverly, 2010; Tucker, 2012; Wentland, 2004).
Tucker (2012) described the flipped classroom as, “While there is no one model, the core idea is to flip the common instructional approach: With teacher-created videos and interactive lessons, instruction that used to occur in class is now accessed at home, in advance of class. Class becomes the place to work through problems, advance concepts, and engage in collaborative learning” (p. 82).

This transformation provides students with the opportunity to actively engage in the content and allows students to think about the ideas presented in the videos. The basic idea behind a flipped classroom is very simple: normal classroom activity now occurs outside the classroom and typical out of class activities now become in-class activities. Bergmann and Sams (2012) stated, “the one unifying characteristic of all flipped classrooms is the desire to redirect the attention in a classroom away from the teacher and onto the learners and the learning” (p, 96). Tucker (2012) noted that a flipped classroom is a comprehensive approach to teaching that involves instructional videos firmly integrated with purposeful classroom activities which involve active learning techniques.

Bergmann and Sams (2012) distinguished between a flipped classroom and a flipped-mastery model. The difference between the two models is that in the flipped-mastery model student’s work at their own pace and not at the pace of the curriculum creating a self-directed learning environment. Flipped classrooms provide opportunities for students and teachers to have more time to interact which allows students and teachers to learn from each other and for weak students to get more one-on-one help (Bergmann & Sams, 2012). Students can pause, rewind, and re-watch videos as often as necessary and
all students receive assistance in this model, not just the most verbal or motivated
learners (Bergmann & Sams, 2012).

**Flipped Classroom Characteristics**

The literature presents key characteristics of a flipped classroom. This section
highlights the concerns regarding the current teaching and learning environment in select
teachers’ classrooms, the lack of success of students in those classrooms, the new
structure within the flipped classroom, active learning activities, and the different roles
that both students and teachers take on.

The flipped classroom emerged in response to teacher frustrations regarding
meeting the needs of more learners, all the while attempting to cover the ambitious
amount of content that is required to be taught to students. For example, the majority of
economics classes are lecture style classes with a predetermined amount of content to
teach each semester and very limited time constraints (Lage, Platt, & Treglia, 2000).
Instructors in those courses were concerned about the number of unsuccessful students
each semester and the struggle of meeting the needs of the variety of learners while
simultaneously teaching the predetermined curriculum. These same struggles occur in
numerous classrooms and disciplines on a daily basis, including my own. It is also argued
that economics should not be taught to only one learning style as are many classes
through lecture teaching (Lage et al., 2000).

To address these concerns, Lage et al. inverted an economics classroom. They
created lectures for at home viewing via a variety of formats: PowerPoint’s, VCRs, web,
etc. They began this new teaching model each day with a question and answer session
regarding the video lectures. When necessary and appropriate, the instructor would
provide a short lecture to supplement the video lectures. If students did not have questions, it signified that they understood the lecture. The question and answer session was typically followed by an experiment, or a lab which previously would have been completed outside of class. Time was allotted for review questions and worksheets each day.

Much of the class time in a flipped classroom is devoted to students working collaboratively to complete the required in-class assignments (Tucker, 2012). As such, the flipped classroom incorporates more active learning strategies (Lage et al., 2000) and becomes an individualized learning environment (Bergmann & Sams, 2012). This model of teaching and learning greatly increased valuable contact time between the students and the instructor and encouraged analysis and synthesis of mathematical ideas supporting a constructivist framework (McDaniel & Caverly, 2010). Furthermore a flipped classroom strives to be more student centered, time saving, and integrate individual and/or group activities (Wentland, 2004). It is stated that the flipped classroom is more efficient than the traditional classroom as valuable class time is not devoted to students attempting to follow the lecture, transfer notes from the board to their notebook, and apply the newly presented information (Bergmann & Sams, 2012). Every minute of class is utilized for the students to engage in active learning. Instructors are able to create a more accurate representation of what students do and do not know and where potential misunderstandings may be occurring due to the increased opportunity to communicate with all students in the class, not just those that choose to participate.

With the course redesign, instructors are no longer lecturing during class. Now, students are watching the lectures for homework and completing the homework in class.
Since instructors are no longer lecturing during class, a significant amount of class time is freed up for different roles for both students and teachers. The instructors and teaching assistants are available as a resource for questions as students are working through the application of lecture content (Foertsch, Moses, & Strikwerda, 2002). In the traditional lecture model, students typically struggle through the application of lectures on their own. This model of teaching provides the instructor with the ability to interact with all students (Bergmann & Sams, 2012), form an accurate representation of what students do and do not know, and provide specific real-time feedback to students (Foertsch et al., 2002).

Instructors that have flipped their classrooms have integrated and utilized a variety of in-class activities to enable students to utilize and apply information learned in the video lectures. For example, a chemistry teacher who flipped his classroom requires his students to take notes on all videos and create a question to be addressed in class as motivation to watch the lectures (Bergmann & Sams, 2012; Tucker 2012). Another approach involves students broken into groups and each group is required to summarize the video lecture and orally report back to the entire class (Wentland, 2004). A flipped mathematics classroom uses worksheets, group work, and graded board work for in-class activities (McDaniel & Caverly, 2010). Instructor’s in Lage et al.’s (2000) study compiled additional resources and posted them on the web for students to access. Quizzes were also uploaded for students to assess themselves on the objectives while doing work outside class. Classroom Assessment Techniques (CAT’s) (Angelo & Cross, 1993) are active learning strategies that can also be implemented within the classroom. The perspective is that valuable learning activities can be completed within the additional class time without sacrificing content coverage.
Review of Research

Research on flipped or inverted classrooms is expanding daily. A search of the literature exposed numerous studies that were completed regarding flipped or inverted classrooms, the majority occurring in higher education. One study completed by Clark (2015), occurred in two algebra I courses at a rural high school. Of the research examined, five studies were interested in determining student perceptions in the flipped classroom (Cummins-Sebree & White, 2014; Foertsch et al., 2002; Kim, 2014; Lage et al., 2000; Tattersall, 2015). Five studies compared the flipped classroom to traditional teaching. Of those, Harrington, Bosch, Schoofs, Beel-Bates, & Anderson (2015), Seyedmonir, Barry, & Seyedmonir (2014), and Clark (2015) compared course grades and other quantitative assessment data to determine if there was a difference between the two teaching methodologies. Mattis (2014) also compared the flipped classroom to traditional teaching but only compared accuracy and mental effort on mathematical problems of second year nursing students. Although Strayer (2012) compared the flipped classroom to traditional teaching, he was using the comparison to inform teaching practice not to compare quantitative outcomes.

Several researchers were interested in the mechanics of flipping the classroom, specifically the advantages and disadvantages (Moran & Milsom, 2015), while others wanted to determine what was effective and what works to teach other faculty interested in flipping their course (Velegol, Zappe, & Mahoney, 2015). McCallum, Schultz, Sellke, & Spartz (2015) were interested in finding out the connection between the flipped classroom and students’ academic involvement, such as note-taking, watching of video lectures, and collaboration with in-class activities.
In each of the studies, the flipped classes were undergraduate students enrolled in: microeconomics (Lage et al., 2000); engineering problem solving (Foertsch et al., 2002); introductory statistics (Strayer, 2012); research methods and statistics I (Cummins-Sebree & White, 2014); medical surgical nursing (Harrington et al., 2015); engineering, social studies, and humanities (Kim, 2014); second year nursing students (Mattis, 2014); calculus with pre-calculus I, calculus with pre-calculus II, and a business management course (McCallum et al., 2015); principles of biology (Seyedmonir et al., 2014); environmental engineering (Velegol et al., 2015) and two communicative sciences disorders class (Tattersall, 2015) where one was at the undergraduate level and the other at the graduate level. Moran and Milsom’s (2015) study occurred in a graduate level foundations of school counseling course.

It is evident that the research that exists was conducted on upper level students, not on entry level freshmen deficient in basic skills. Additionally, the majority of participants in each of the studies was white and not historically underrepresented students. One study was conducted at a historically African-American university (Seyedmonir et al., 2014). The literature does not tell us what impact a flipped classroom has on economically and educationally disadvantaged students. No research currently exists on an at-risk population of adult developmental learners in higher education.

The information below illustrates the findings from the studies mentioned above that have been completed regarding flipped classrooms. Three themes emerged from the literature: perspectives from teachers, student perceptions, and comparative findings.

_Perspectives from Teachers_
Each of the studies examined presented insights from the perspective of the flipped classroom teacher based upon self-reflection and interviews. Teacher perceptions revealed that faculty had more time to interact with students, which in turn increased motivation to learn the subject. It was also noted that the faculty liked teaching in this model.

Course instructors found that they had more time to interact with students on an individual basis within the inverted classroom (Lage et al., 2000; Moran & Milsom, 2015) as they are able to speak with each student in every class and also have time left to work with struggling students (Tucker, 2012). McDaniel and Caverly (2010) noted that the increased contact time between faculty and student increases student motivation to learn. Instructors felt that the additional student contact enabled them to clarify misunderstandings (Lage et al., 2000) and benefitted student learning (Moran & Milsom, 2015). Advocates for a flipped classroom claim that this model: improves student motivation, engages students, and improves relationships in the classroom as compared to traditional classrooms (Tucker, 2012). Instructors in Lage et al.’s (2000) study noted that the transfer of responsibility in the inverted classroom moves from instructors to students and that is likely for the increase in student motivation. This approach was found to facilitate a cooperative learning environment and it encouraged the students to become active participants in the learning process (Strayer, 2012).

When it came to strengths, instructors noted that the “course was considerably more stimulating to teach” (Lage et al., 2000, p. 37). Furthermore, faculty found it more interesting to teach the in-class labs as opposed to teaching the lectures because “the material is not simply fed to students in a one-way monologue” (Foertsch et al., 2002, p.
The instructors felt that their interactions with the students were rich and organic as opposed to one-sided. Also, faculty evaluations showed significant improvements in the course as students felt the online lectures were useful, the professor was attentive and helpful, and that they would recommend the professor and the course (Foertsch et al., 2002). Course instructors found that female students were more comfortable and assertive in the inverted classroom as opposed to the traditional classroom (Lage et al., 2000).

A concern identified by teachers who use the flipped classroom is the increase in preparation time and amount of work for faculty and TAs practicing a flipped classroom, most significantly in the beginning (Cummins-Sebree & White, 2014; Foertsch et al., 2002; Lage et al., 2000; Moran & Milsom, 2015). Faculty noted that searching the internet for appropriate videos was exhausting (Moran & Milsom, 2015). Preparing and creating video lectures for each objective was also found to be time consuming as well as learning the appropriate technology to create the video lectures (Moran & Milsom, 2015). The duration of video lectures for one study was found to be half as long as the length of a traditional in-class lecture (Foertsch et al., 2002). This could be due in part to the fact that there are no students interrupting to ask questions during the videos. Other concerns about video lectures is the lack of a live audience during the video lectures, teachers cannot take cues from the students regarding the pace of the lecture.

The literature illustrated that faculty embraced the additional time with students during class. However, the research did not address how classroom teachers planned for neither the additional class time nor the task of preparing for facilitating meaningful activities. It would be informative to know what activities were used regularly during
class as well as what adaptations are necessary for the instructor and/or for the students. Are faculty and students experiencing success by flipping the classroom? How are faculty structuring the flipped classroom model? How is the flipped classroom working for them? What were the problems and how did the educator overcome those issues? Is class participation problematic in a flipped classroom? How do teachers keep students on-task daily? What improvements occur in a flipped classroom either with the content and/or students? Will flipping the classroom impact success in developmental mathematics? All of these questions are concerns that remain for a teacher transitioning to a flipped classroom.

**Student Perceptions**

Research revealed that the majority of students liked the inverted classroom. Students stated that they would prefer to continue learning in an inverted classroom (Clark, 2015; Cummins-Sebree & White, 2014; Lage et al., 2000; Velegol et al., 2015). Furthermore, students liked the ability to learn from their peers and have their perspective on the problem solving process and application of lecture content (Foertsch et al., 2002; McCallum, et al., 2015; Strayer, 2012). One student commented, “As for the class itself, I loved the way it was run! The groups were very effective – it helped to have your peers explain things to you in a different way that sometimes made more sense. Also, it was easier to get to know your classmates and made for a very comfortable environment. I liked the ‘hands-on’ approach” (Lage et al., 2000, p. 35). Students in Foertsch et al.’s study also liked the group work because if they knew something well, it helped them to learn it better when they explained it to a group member. Also, students seem to like the in-class activities and labs because they would normally have completed them on their
own outside of class and struggled (Foertsch et al., 2002). A student commented, “I believe that I learned more economics with this classroom format” (Lage et al., 2000, p. 35). Another student said, “I really liked the demonstrations and the group work – they helped me to really see the concepts, much better than a lecture would, and I could better visualize something I’d seen rather than heard – that was a big plus for tests” (Lage et al., 2000, p. 35). With the course redesign, now students are completing their out of class activities in class, and the instructors and teaching assistants are available for questions as they are working through the application of lecture content (Foertsch et al., 2002). Students noted that they felt more comfortable seeking the instructor out for assistance and feedback in the flipped classroom (McCallum et al., 2015).

Students noted that the flipped classroom requires a lot of responsibility on their part and increases their workload (Seyedmonir et al., 2014) However, three-quarters of the students in Foertsch et al.’s (2002) study noted that the flipped course did not take up more time for them than the traditional class. Data in that study demonstrated that 64% of the students felt that it was just as easy to take notes from an online lecture as it is during a traditional lecture and that the course required a higher level of responsibility from them because they were responsible for actively watching the lectures on their own. A student commented,

I really enjoyed the class setup and structure. I was a little nervous after the first day of class when we talked about how much responsibility is required for this class, but it wasn’t as bad as I thought. I really enjoyed the labs and worksheets that we do in class because it really helped me understand the chapters. It also really helped as a study-guide for exams.
I also like the way the class is sort of informal because it makes me feel more comfortable asking questions. (Lage et al., 2000, p. 35-36).

Students noted that the quality of instruction in the flipped classroom was better than in a traditional class (Clark, 2015). This could be due in part to the additional contact and feedback with faculty and peers as well as the active in-class learning environment.

Students felt that the flipped classroom supported their academic success (McCallum et al., 2015). They liked the ability to watch the lectures when it was best for them and their schedule and at a pace that was comfortable to the student (Foertsch et al., 2002; McCallum et al., 2015; Seyedmonir et al., 2014). Students also noted that they would rewatch the videos to prepare for exams and quizzes (Clark, 2015; Cummins-Sebree & White, 2014; McCallum et al., 2015; Velegol et al., 2015). They also commented that they liked having a preview of the lesson and that helped them to feel more prepared for class (Cummins-Sebree & White, 2014; McCallum et al., 2015).

The students’ perspective also noted shortcomings to this model of teaching and learning. One disadvantage to the online lectures was the inability to ask questions immediately during the lecture like they could with a traditional lecture (Foertsch et al., 2002; Seyedmonir et al., 2014). Foertsch et al. also found that 16% of the students felt that the online lectures negatively affected their learning. Students in that same study felt as though they were not as attentive to the lectures because they were also provided with printed notes and that traditional lectures provided a better level of accountability that encouraged a more refined level of interest and attention. Since online lectures can be watched in their pajamas and in bed, students felt like they did not pay as close attention.
Strayer (2012) flipped his classroom and used Assessment and LEarning in Knowledge Spaces (ALEKS), a web-based tutoring and learning system for mathematics and other subjects, for his video lectures. The students felt a disconnect between the online lectures and class activities. He stated that, “inverted classroom students completed a number of different types of learning activities throughout the semester” (p.181). Since the lectures, homework, and in-class activities were different from each other, students had difficulty finding coherence between all components. Strayer noted, “all of this varied activity influenced the culture of the classroom so that students never really settled into a pattern for ‘how to do class’. At times, students clearly did not know what to expect or where class was going” (p. 181). Was the confusion on the part of the students due in part to the fact that the video lectures were from a standardized web-based tutoring program and not from Strayer’s curriculum? Were objectives presented differently in ALEKS than they were in class and were certain items valued more than others between ALEKS and class activities? Strayer stated that students in an inverted classroom require support due to the disconnect between in-class learning activities and video lectures. He recommended that it is important for classrooms to integrate online technology (i.e. discussion boards) to make sure there is an alignment between the online and in-class portions. However, if the online and in-class portions are well aligned (which was not the case in this study) would he still make that recommendation? Kim (2014) recommends that out of class videos and in-class learning activities are structured so there is a connection and relevance between the two.

The concern about outside lectures identified by faculty and students raises some questions about the flipped classroom, such as: What aspects of the online video lectures
hindered their learning? What is the impact of not being able to ask questions during the lecture? Is it the student’s lack of attention paid to the lectures that had a negative impact upon learning? What are the effects for students who do not watch the lectures?

**Comparative Findings**

This section will focus on the findings from the studies that compared their traditional classrooms to flipped classrooms. There were five studies that contrasted traditional teaching to flipped classrooms.

Clark (2015) measured student engagement and performance in two algebra I courses at a rural high school. He found that students scored similarly on unit tests when comparing the flipped class to the traditional class. Clark noted that performance measures between the flipped classroom and traditional classes were insignificant. Harrington et al. (2015) also compared a flipped class to a traditional class for a medical surgical nursing theory course. They did not find any statistical differences between the flipped class and the traditional class. They determined that the flipped classroom was just as effective as traditional teaching. Velegol et al. (2015) conducted a case study in a large environmental engineering course. They compared final exam scores across six semesters. Half of those semesters were traditionally taught while the other half was taught using a flipped classroom. Velegol et al. found no significant differences in final exam grades across semesters. They did note that the final exam was not the exact same final for all classes. They remarked that they tried to make them as similar as possible but no statistical data was mentioned to determine similarity.

Two additional studies that conducted comparative analysis of flipped classrooms versus traditional teaching were examined. Seyedmonir et al. (2014) flipped a principles
of biology course at a historically African-American university. They compared the flipped class to a previous semester of the same class that was traditionally taught. Seyedmonir et al. did not find any difference in exam scores between the flipped class and the traditional class. They did however, find that students in the flipped class did better on real-world, application type questions. The second study conducted by Mattis (2014) utilized a flipped classroom structure for second year nursing students in preparation for a mathematical competency exam. She found that the flipped class was more accurate on their posttest than the traditional class. Mattis also found that the flipped class was more effective with moderately to highly complex problems. Both of the studies mentioned here found that the flipped classroom was more effective with higher order thinking and problem solving. What is it about the flipped classroom that enables students to think and reason through those more complex problems?

**Suggestions for Implementing Flipped Classrooms**

The literature reviewed provided suggestions for transitioning traditional lecture style classes into a flipped classroom. Their suggestions included recommendations on lecture media and motivation, as well as ways to manage workload.

For educators considering flipping their classroom, the task can seem overwhelming. One question that may help practitioners begin to conceptualize this model is, “which activities that do not require my physical presence can be shifted out of the class in order to give more class time to activities that are enhanced by my presence?” (Bergmann & Sams, 2012, p.96). Students do not usually need assistance to take notes or listen to a lecture. It is not uncommon, though, for students to proclaim how well they understood the concepts or ideas during class but when they attempted the homework on
their own later, they struggled. Listening to a lecture and taking notes is a passive
learning activity that does little to engage students in the content. Any active learning
strategy that engages the students in the content or asks them to process information and
apply it will present a challenge for the students. It is precisely those activities where
students will need assistance to promote meaningful learning. Unfortunately, in the
traditional classroom students are usually assigned those more important active
processing activities to complete on their own outside of class. The flipped classroom
works to upset that pattern.

Almost two-thirds of students in one study (Foertsch et al., 2002) noted that the
flipped classroom required them to be more responsible than a traditional classroom. Part
of that increased responsibility was linked to the student’s obligation to watch lecture
videos outside of class. Teachers were concerned that students would not commit to
watching the video lectures regularly. In an attempt to alleviate this concern, Bergmann
and Sams (2012) teach students how to watch and interact with the videos. They
suggested watching a couple of videos as a class and teaching them how to take notes
from it. This simple activity will reinforce the value of the video lectures and promote a
good work ethic among the students in regards to the lecture videos. Educators also
noticed that students would get discouraged watching lengthy lecture videos. Therefore,
they recommend that educators should not only ensure that their videos are short and
focus on one objective each (Bergmann & Sams, 2012) but also provide enough
background knowledge so that the students are prepared to begin the in-class activities
(McDaniel & Caverly, 2010). Educators noted how time consuming it is creating each of
the videos necessary for a class. Instructors could reduce their workload by utilizing
some textbook resources as well as internet resources in the development of their videos for the flipped classroom (Lage et al., 2000).

The video lectures are an essential component to the flipped classroom and an integral part of all classroom activities. Additional suggestions for implementing a flipped classroom revolved around motivating students to watch and interact with the lecture videos and monitoring their participation with the videos. A notebook check is done in both Bergmann and Sams (2012) classrooms to make sure students are watching the videos. Kim (2014) recommends assessing student understanding on out of class work. Some faculty developed weekly online quizzes whose sole purpose was a motivational tool to encourage students to watch the video lectures (Foertsch et al., 2002). Students who do not watch the video prior to coming to class watch it during class while other students are working on homework (Bergmann & Sams, 2012). Non-watchers then have to do homework outside of class and Bergmann and Sams noted that many of those students realize the importance of needing instructor help with homework.

Some educators also expect students to come to class and ask one question they thought of while watching the video (Bergmann & Sams, 2012; Lage et al., 2000) to ensure they are interacting with the video lecture. What do educators do though, when students do not have questions? Do they enforce this practice? If so, how? Another recommendation was to use online discussion boards to encourage students to discuss course content outside of class as a reflective activity (Strayer, 2012). Would students take advantage and/or use such a service in a math course? Is the discussion board configured for seamless entering of mathematical symbols? Is the electronic submission of mathematical ideas inhibiting discussion rather than encouraging it?
Students recognized the significance of the video lectures and they desired flexibility and mobility in regards to the lectures. They wanted the ability to view the lectures on smaller devices, to have access to the lectures without having to go through the internet, to know how long the lectures were, and how much time was remaining (Foertsch et al., 2002). The students also suggested allowing them the opportunity to rewind or fast forward the lectures so they could adjust the lecture for their learning pace.

Educators noted how time consuming it is creating each of the videos necessary for a class. Instructors could reduce their workload by utilizing some textbook resources as well as internet resources in the development of their videos for the flipped classroom (Lage et al., 2000).

**Challenges and Limitations of a Flipped Classroom**

Despite appreciation by students in regards to the amount of teacher attention during class, research has shown that student motivation to utilize and watch online lectures was low (Strayer, 2012). However, Lage et al. (2000) noted that students in their study were watching and interacting with the videos. They noted that earning good grades motivates their typical students. As a result, their students were watching and interacting with the videos so they could perform well in the course.

Students were expected to come to class with one question they thought of while watching the video (Bergmann & Sams, 2012). How are students held accountable for something like that? It could get very time consuming checking to make sure that all students are recording their questions and bringing them to class for discussion. Students also commented that they were not as attentive to online lectures (Foertsch, 2002). With the number of distractions vying for students attention (social networking, cell phones,
video games, etc.), it is understandable that students get distracted. Is this a big enough concern that faculty become involved?

Each of the studies examined used labs and other in-class work that required students to work together. They did not articulate if it was difficult keeping the students on-task on a daily basis and if the students became restless because they were continually required to work collaboratively throughout the semester. They also neglected to discuss whether they had to teach the students to work cooperatively and how they conquered this problem if it occurred. This raises questions, such as: Were the students resistant to the different class structure? If so, how did they mitigate that challenge? What aspects of this model of teaching were most challenging for instructors? Did faculty struggle to design effective, engaging, in-class learning tasks that captured the attention of their students?

More than half of the students in Foertsch et al.’s. (2002) study noted that the online lectures helped them and their learning in the course. But what helped the students to learn? Was it the online lectures and the ability to pause, rewind, and re-watch them, more in class attention from the instructor, the ability to apply the learning from the lecture in class with support from the instructor and peers, or a combination of everything that helped the students learning? Details were not provided as to why those students felt the video lectures were an effective pedagogical tool.

Currently, numerous conceptual articles exist that advocate implementing this model of teaching and learning. However, the research that exists was conducted on upper level undergraduate and graduate level students who are adequately prepared for college level coursework. That population studied is neither diverse nor representative of
the students sitting in classrooms across the country. As such, students enrolled in those courses are prepared for college level work and typically do not encounter the same learning challenges and difficulties that underprepared students experience. The classrooms studied illustrate its effectiveness in upper level coursework. What does it look like in a developmental classroom serving the most at-risk population in higher education?

*Flipping the Classroom*

It is apparent that students have difficulty learning mathematics within the current learning structure as evidenced by the number of students enrolled in developmental mathematics and the amount of research that exists on the topic. The courses I teach are structured using a transmission model of learning with me conveying mathematical knowledge to my students. Within my classroom, students are usually busy trying to keep up with the breathtaking pace while at the same time attempting to copy all information into their notes. Throughout class there is little to no time for students to process information, they are simply expected to soak up all information like a sponge and be motivated to explore the ideas on their own outside of class. Much of the research that exists approaches developmental mathematics with the perspective that the students and developmental programs are broken as they try to implement practices that will support students within the current teaching model. Perhaps, though, the model of teaching is broken and not the students.

Some studies (Galbraith & Jones, 2006; Higbee & Thomas, 1999; Kirk & Lerma, 2010; Weinstein, 2004) have transitioned from traditional classrooms and integrated constructivist teaching practices within their classroom which offered students the
opportunity to process the information, consider the ideas, and work towards an understanding. Both national mathematical organizations, American Mathematical Association of Two-Year Colleges (AMATYC) and National Council of Teachers of Mathematics (NCTM), along with current research suggest that students need time to process information, they should wrestle with ideas, and collaboration in the classroom encourages both of those. This does not mean that lecture teaching is completely discredited, simply that it should be questioned within the current teaching model. What would happen if educators could combine the best of both worlds? A flipped classroom does exactly that. Within a flipped classroom, students still participate in lecture teaching to gain introduction to ideas but they also have the opportunity to process information within a collaborative environment. A flipped classroom requires students to accept responsibility for the lecture by watching pre-recorded lessons outside of class. During class, students work towards understanding and making meaning from the ideas presented in the lecture. The flipped classroom allows class time to be used more efficiently and increases the interactions between faculty and students and students to students (Foertsch et al., 2002; McDaniel & Caverly, 2010) and engages students in higher order thinking skills (McDaniel & Caverly, 2010).

Summary

The purpose of this action research study is to explore a constructivist, flipped approach to teaching developmental mathematics. Five major bodies of literature were reviewed in this chapter: constructivism, community of mathematical inquiry, developmental education, developmental mathematics, and the flipped classroom. Constructivism serves as a grand theoretical framework that relates to the study in two
different ways: cognitive constructivism with the out of class video lectures and social constructivism with the in-class collaborative activities. A community of math inquiry also informs the study through the discussion and dialogue of in-class work where the focus of learning is not on memorization but rather understanding of mathematical concepts (Kennedy, 2009). A CMI occurs within each student’s zone of proximal development and the students are scaffolding each other’s learning through dialogue (Kennedy, 2009).

The literature regarding developmental education provided background knowledge to understand the context in which the study will be set. Developmental education is pivotal to a democratic society as it works to educate all citizens, especially those learners that are underprepared and educationally marginalized (Boylan, 1999). Individuals seeking educational opportunity, with the desire to earn a degree, but lacking the necessary skills would remain marginalized and disadvantaged without developmental education programs and support (Boylan, 1999). Developmental education targets a large adult population but few empirical studies address or mention adult students.

A review of developmental mathematics literature showed that developmental mathematics prepares students for subsequent college level mathematics courses (Waycaster, 2001). Developmental mathematics students do as well or better than their non-developmental peers in college level courses (Waycaster, 2001). Unfortunately, students feel as though they have difficulty understanding the content delivered via lecture during class, that it is not making sense at that time (Weinstein, 2004). Students should be working collaboratively and using each other to construct mathematical
knowledge (AMATYC, 1995; Higbee & Thomas, 1999). It is imperative that students achieve success in developmental mathematics courses. Creating successful students in those courses allows them access to a wider array of career choices and empowers students (AMATYC, 1995).

The empirical literature on flipped classrooms is very limited and occurs in either secondary education or upper level higher education courses. For those studies set in higher education, none of them occurred in a developmental classroom. The flipped classroom is an efficient, individualized learning environment (Bergmann & Sams, 2012; Wentland, 2004). By moving the lecture outside of class, the flipped classroom frees up class time where the instructor and the students can interact and learn from each other (Foertsch et al., 2002). This increase in contact time between faculty and students increases their motivation to learn (Lage et al., 2000; McDaniel & Caverly, 2010).

This chapter has demonstrated that no research currently exists using an action research methodology in developmental mathematics as well as exploring a flipped classroom situated in developmental education.
CHAPTER 3

METHODOLOGY

The purpose of this study was to explore a flipped classroom approach to teaching developmental mathematics. This chapter begins with the research questions. Next, I discuss the qualitative research paradigm, followed by a detailed description of the research methodology, action research. Background of the researcher will be provided as well as the setting of the study, planned course structure, media selection, pilot video lesson, initial video lessons, participant selection, data collection, and data analysis. This chapter concludes with trustworthiness of the study.

Research Questions

1. How can a flipped classroom be successfully implemented within a developmental classroom?

2. How does a flipped classroom, from the perceptions of adult developmental learners, promote a community of math inquiry in a developmental mathematics classroom?

3. What are the perceptions of adult developmental learners concerning the flipped classroom and the impact on learning for developmental mathematics?

4. What practical strategies were most effective at facilitating a flipped classroom from the students’ and faculty member’s perspective?

5. What is the degree of satisfaction of the flipped classroom from the student’s perspective?
Qualitative Research Paradigm

This action research study was guided by a qualitative research paradigm. Qualitative research is “suited to promoting a deep understanding of a social setting or activity as viewed from the perspective of the research participants” (Bloomberg & Volpe, 2008, p.7-8). Qualitative research is focused on understanding the nature of a problem or issue (Hathaway, 1995; Merriam & Simpson, 2000). It respects the complexity of the situation and context and how each influences the other including the participants and the researcher. Qualitative research aims to understand deeply from the perspective of those closest to the phenomenon (Hathaway, 1995; Patton, 2002). My experience as a developmental educator provides an intimate perspective that will be invaluable when studying the flipped classroom. Through implementing the flipped classroom within my practice, I will be able to develop a thorough understanding of the flipped classroom as well as its presence within developmental math education.

Qualitative researchers believe that theories can be developed through in-depth understandings about issues and problems rather than generalizing across large populations. The information gained from qualitative research is rich as it allows for insight from a specific perspective or context (Patton, 2002). The understanding that is created is directly tied to the social context, experience, and participants. The qualitative research paradigm will allow me to thoroughly understand how a flipped classroom approach can be implemented, the related challenges, and how effective it is at helping learners to be successful in developmental mathematics. This concern warrants further exploration within this specific context which supports an action research methodology.
Qualitative research is constructivist in nature as it holds the assumption that reality is constructed by the individuals (Bloomberg & Volpe, 2008; Hathaway, 1995). There are many perspectives within qualitative research as opposed to one absolute truth. Truth in qualitative research is how the participants see, create, and perceive it (Merriam & Simpson, 2000). Therefore, knowledge construction is dependent upon the learner’s perception and each learner’s perception could be different (Fosnot, 1996; von Glasersfeld, 1996). The learning is anchored to the environment in which it is embedded (Powell & Kalina, 2009) because the context significantly affects the learning and knowledge that is constructed (Liu & Matthews, 2005). According to Merriam & Simpson (2000), “reality is constructed by individuals in interaction with their social worlds” (p. 97). Those realities are studied and examined in an effort to understand how others make meaning of their reality.

One advantage to utilizing qualitative research is that it is flexible and less rigid than quantitative research. Qualitative research allows for change during the research process and it is conducted within the environment which enables the researcher to observe the dynamics of what is being studied in that context. Another core characteristic of qualitative research is that, “the researcher is the primary instrument for data collection and analysis” (Merriam & Simpson, 2000, p. 98) rather than being removed from the situation (Willis & Neville, 1996). Qualitative researchers understand the situation and are directly involved in all aspects of the research (Hathaway, 1995). They are active and participate in the research and are not simply observers because they are an instrument in the research (Hathaway, 1995). This research does not attempt to sterilize the research by removing bias but rather appreciating the researcher’s
subjectivity and its role and relationship in the research process. Knowledge created within a qualitative research paradigm is dependent upon the participant’s perception and each perception could be different and is influenced by the other participants and context (Fosnot, 1996; von Glasersfeld, 1996). During qualitative research, data is usually collected one of three ways: through interviews, observations, and related documents (Patton, 2002). Qualitative researchers work to develop an understanding of the phenomenon under study through analyzing data and creating themes/categories from the data analysis.

Qualitative research is most appropriate for this research project for two significant reasons. First, I want to improve the practice of teaching mathematics because only half of the students who enroll in developmental mathematics complete it successfully (Fike & Fike, 2007) and mathematics is the deficiency that is most influential in determining the successful completion of the degree program (AMATYC, 1995; Duranczyk, 2007; Fike & Fike, 2007).

The flipped classroom shows promise for developmental mathematics as it grants students the luxury of engaging in video lectures at their pace as opposed to the pace set by the instructor or dominant members of the class. It also affords students the time to begin to process mathematical ideas before applying them and allows students the ability to re-engage with previous lectures and content they may be struggling with.

The second reason for selecting qualitative research is because I want to understand the flipped classroom within the context rich environment of developmental mathematics. I am not simply implementing a treatment program and examining a cause
and effect relationship. I am an instrument in the research as a developmental mathematics instructor.

When exploring a new technique or idea there is a need to be able to change the research as the study is advancing in order to meet the needs of the teacher-researcher and the students. This research was dynamic and changed to meet the needs of both myself and my student participants. Since the objective was to explore a flipped classroom in developmental mathematics, there is a compelling need to understand the researcher’s values and bias and how they have influenced the practice of teaching. Action research is the research methodology that was chosen as the best fit because the goal was to learn from the situation not to generalize beyond this situation.

Research Methodology: Action Research

Carr and Kemmis (1986) stated that, “it is practice that determines the value of any educational theory, rather than theory that determines the value of any educational practice” (p.126). Action research provides the opportunity to unite theory and practice and to do so simultaneously while the research is being carried out. It is unique as it values and incorporates the perceptions and intuitions of the teacher. The focus with action research is about growth, both personally and professionally. It assumes that the teacher herself knows best what to research and has the best understanding of the context and the students. As a developmental mathematics practitioner, my perspective is valuable and provides knowledge to the field as my experience lends insight and creates knowledge valuable to developmental education. Herr and Anderson (2005) stated that, “practitioners tend to find traditional research, which is based on formalistic generalizations, less useful than narrative accounts from schools and classrooms that
provide them with vicarious experience” (p. 63). Action research allows me to utilize the practical experience and knowledge I have acquired to inform and contribute to educational research and in turn explore a flipped classroom in developmental mathematics.

Action research “is not research about education but research for education” (Carr & Kemmis, 1986, p.155). It is practical research for education as the research can be changed to meet the needs of the participants. Information that is gathered from an action research study can be immediately applied in practice. Action research is creative, active, meaningful, and pragmatic. It rejects the expert researcher and provides the opportunity for the educator to influence research. It gives a voice to both the teachers and the students and creates a more autonomous teacher, researcher, and individual (Kincheloe, 1991). Action research is not seeking a cause-effect relationship but working to improve education through changes in practice.

Action research is deliberate as it seeks to understand the teacher’s practice, context, and situation with all of its assumptions, values, and biases. This examination provides practitioners an opportunity to develop greater awareness of their teaching. It allows the practitioner to honestly see their practice with little distortion that may have been created (Carr & Kemmis, 1986), providing the opportunity for teacher researchers to creatively explore alternative ways to achieve educational success. Effective change can occur by seeing one’s practice in detail and bringing forward the teachers assumptions in an effort to question them and to better understand their own practice (Carr & Kemmis, 1986; Kincheloe, 1991).
There are several core assumptions that are central to action research. First, it is assumed that students will participate fully, freely, and honestly, when the researcher is also the course instructor who ultimately controls final course grades. Second, this methodology is dependent upon the researcher recognizing their subjectivity and its influence upon the study. It is assumed that the researcher will conduct thorough interpretations that accurately represent the context and situation. Next, simply because a researcher is completing an action research study does not necessarily mean that things will improve as a result of the action research. Also, action researchers want to understand deeply about their unique classroom challenges, not generalize across large populations. Even if the same research were carried out again with a different group of students and teacher, the results would likely vary due to the differences of the participants. Once you change the participants, educator, and setting, the values and assumptions change along with them. Regardless, other educators can utilize the process and adapt the methods to their own practice.

Action research is a cyclical process of planning, acting, observing, and reflecting (Kuhne & Quigley, 1997). During the planning phase the teacher researcher works to understand the problem she is trying to solve by viewing the problem from different perspectives and questioning assumptions that affect the practice of teaching (Kuhne & Quigley, 1997). The teacher researcher must also clearly define the problem, identify potential changes to make in practice, and determine how the research will be evaluated (Kuhne & Quigley, 1997). The planning phase requires the teacher researcher to be thorough and proactive to ensure that the problem is adequately understood. Once the planning phase is complete, the teacher researcher begins the action phase, where she
examines whether she is doing what she really planned to do (Kuhne & Quigley, 1997). The action researcher should be keeping good records and collecting adequate data (Kuhne & Quigley, 1997). Throughout the action phase it is necessary for the teacher researcher to continually observe her practice for any changes. The study concludes with reflection and evaluation of the project (Kuhne & Quigley, 1997).

Since action research is a cyclical process, it encourages the teacher-researcher to interrupt the research, to step in, in an effort to make improvements to the practice (Kemmis, 2008). Therefore, as the teacher-researcher goes through the phases above, they are continually revising things, developing a new plan, collecting data, and making changes based upon the data. Through that purposeful interruption, action research is constantly evolving and being shaped to meet the ever-changing dynamics of what and those being studied. Since action research allows the researcher to make changes during the research, the cycle of research can be carried out numerous times whereby evolving the four phases of the research (Kuhne & Quigley, 1997).

Since I wanted to explore the implementation of a flipped classroom in my practice of teaching developmental mathematics, it seemed natural to consider action research as the research methodology for this study. Action research is focused on problems and issues inherent in the environment whether it is a workplace, community, classroom, etc. The knowledge that can be gained from action research is practical and immediately applicable (Carr & Kemmis, 1986; Kuhne & Quigley, 1997). Once the practitioner is informed regarding the issue or problem, changes can be made based upon the findings. Thus, education can be altered to better meet the needs of students. Knowledge gained from action research is intended to inform and guide practice. Action
research’s goal is not to find a clean, easy solution to the problem(s), but to empower the researcher, and potentially the students.

This action research study encouraged me to question, analyze, and understand the flipped classroom in greater depth and detail. It allowed me to examine this model of teaching and learning and to understand the transition and process in creating a flipped classroom with an at-risk population of learners.

Background of the Researcher

My teaching is structured lecture-based teaching. I essentially teach the way that I was taught. As a former mathematics student, I do not ever recall participating in a mathematics course that was not primarily lecture. Lecture teaching is easy, and I am comfortable teaching that way. I find comfort because I am aware of what I need to do to prepare for each lecture and I know how to go about doing it. Paradoxically, I am also uncomfortable because I am failing to meet the needs of too many of my students.

I have been a developmental educator for nine years. Over the course of those nine years I have grown concerned about the lack of success of students in developmental mathematics. Students enrolled in developmental mathematics courses have struggled in previous mathematics courses, doubt their ability to learn such an abstract discipline, and tend to believe that mathematical ability is genetic. Regrettably, many developmental mathematics students will choose an alternative major due to their inability to be successful in mathematics which inhibits their ability to pursue their dreams. I want to continue to evolve and improve the teaching and learning of mathematics in an effort to help students.
I typically provide detailed notes delivered via lecture that represents my constructed understanding of the topic at hand. As an educator, I continually reflect on my practice and I have noticed that it does not seem to matter how well I present the material, students continue to struggle. Considering the fact that developmental students are not prepared to enter college level mathematics courses, it is apparent that developmental students have been unable to learn mathematics this way (Vasquez, 2004). Participation in the Kellogg Institute (an advanced professional development program for developmental educators held at the National Center for Developmental Education), reflection, and evaluation of my teaching prompted me to consider that traditional, lecture based teaching, was not the most appropriate delivery method. Although lecture based teaching seems to be ineffective with my students, it does not mean that lectures do not have a place within the course. I make every attempt to be thorough in my lectures ensuring that students have all background information, definitions, properties, formulas, etc. The process of copying the abundance of information into a course notebook consumes a considerable amount of class time. Valuable class time is wasted presenting and copying basic information and I feel that that activity could be transferred outside of the classroom. There is little, to no time, set aside in the current teaching model for students to process the incoming information and work towards creating an understanding.

I have come to believe that learners must take an active role in the teaching/learning environment. Classrooms that encourage active learning do not consist of the teacher conveying mathematical knowledge. Classrooms of this type shift the educator from an expert with knowledge to be transmitted into a facilitator encouraging
students to become active constructors of knowledge and understanding (Fennema, Sowder, & Carpenter, 1999).

Based upon classroom experience, I felt that a flipped classroom would encourage more success than the current traditional model of teaching. I was interested in practical strategies that would assist me and my developmental education colleagues in the transition. Due to the need to offer more time for students to think and process mathematical ideas, I embarked on the journey of transitioning from a traditional lecturer, to a constructivist teacher within a flipped classroom.

Setting of the Study

This action research study was conducted at a four-year public institution in the northeastern United States. This institution serves approximately 9,000 undergraduate students and has more than 80 bachelor’s degree programs, 20 master’s degrees, and two doctoral programs. Approximately 80% of the student population is Caucasian students.

The developmental courses that I teach are housed in a centralized department of developmental instruction that has two levels each of developmental reading, writing, and mathematics. The centralized department of developmental instruction supervises a program that recruits and serves economically, culturally, socially, and educationally disadvantaged students as determined by university and state criteria. The program in the department of developmental instruction is diverse as more than two-thirds of program students are historically underrepresented individuals.

The departmental coursework serves both program and regular admission students. Course enrollments are capped at 20 students for the lower level developmental courses and 25 students for the upper level developmental courses. The courses are
either taught three days a week for 50 minutes or two days per week for an hour and fifteen minutes. The majority of the students are traditional age. Approximately five percent of the institutions’ student population is adult students aged 25 years or older.

Planned Course Structure

This action research study focused on shifting from a traditional lecture based classroom into a collaborative mathematical learning environment with the inclusion of the flipped classroom in an Intermediate Algebra class. This transition began with the lectures relocating to out of class work in the form of educational videos that students watched prior to coming to class.

I expected some resistance from the students as this is a substantial change to what they were accustomed to experiencing. It is also important to note that the flipped classroom presented a significant change for me as well. I planned to gradually implement a flipped classroom in an effort to provide a transition period for both myself and the students.

The workload in attempting to flip the entire course was overwhelming and discouraging. Since this study occurred in a 15-week semester where class was held Monday, Wednesday, and Friday, I flipped Wednesday’s lessons during the first two weeks with the exception of the first day of class. Rather than feeling rushed on the first day of class discussing course requirements, explaining the syllabus, and teaching how to solve linear equations, I flipped the very first lessons on solving linear equations. The following two weeks (three and four) I flipped the lessons for Monday and Friday. During weeks five through fourteen I flipped each lesson. The table below illustrates the classes that were flipped during the semester:
<table>
<thead>
<tr>
<th>Week</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Monday &amp; Wednesday</td>
</tr>
<tr>
<td>Week 2</td>
<td>Wednesday</td>
</tr>
<tr>
<td>Week 3</td>
<td>Monday &amp; Friday</td>
</tr>
<tr>
<td>Week 4</td>
<td>Monday &amp; Friday</td>
</tr>
<tr>
<td>Weeks 5 - 14</td>
<td>Monday, Wednesday, &amp; Friday</td>
</tr>
</tbody>
</table>

This schedule allowed both me and the students the opportunity to adapt to this new teaching and learning model. The gradual implementation offered both the traditional lecture and the new flipped classroom.

Classroom activities no longer focused on passive learning through listening to a lecture. Rather, students were engaged in active learning strategies such as: problems of the day, error analysis, notes comparison, three questions from homework, roundtable exercise, informal/ungraded quizzes/exams, creation of practice quizzes/exams, minute paper (Angelo & Cross, 1993), jigsaw, and thought provoking questions. (See Appendix D for a detailed description of each active learning strategy to be used.) The active learning strategies utilized individual, partner, small group, and whole class discussion and presentations. It was the intent to encourage students to listen, share, synthesize, question, write, justify, defend, and discuss in class each day as opposed to just listening and writing.

Students were not simultaneously copying notes and processing incoming information in the classroom. They were expected to apply what they learned in the video lectures during the various in-class learning activities. Class began with the problems of the day (PODs). POD’s are usually review questions that were used to help establish routine and allow the instructor to see what concepts the students may be struggling with. The direction class took after the POD’s varied each day. When
students appeared to be finished with the POD’s, class time was devoted to working through several example problems. When I felt that I had time, I utilized one of the in-class learning activities (Appendix D). Class time was primarily a work session where the students and the groups were expected to complete an in-class activity. Each of the in-class learning activities was time consuming and used a large portion of class time. On days when there was a quiz scheduled we typically only had time for POD’s and reinforcement of learning objectives with example problems. While students were working on the in-class learning activities, I circulated throughout the classroom to offer assistance, address concerns, check notes from the videos, and conduct mini lessons. When necessary, I would interrupt the class and conduct whole class discussions, reteach a concept to expand an idea, or clarify misunderstandings. I vigilantly monitored all groups to keep them active. When groups appeared to be finishing, I would direct them into the next learning activity. I attempted to use all 50 minutes productively every day.

The tables below illustrated a tentative schedule for the first two weeks of the semester. Since action research is flexible and evolving, the tables were provided simply as a guide.

Monday, August 25, 2014:

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>211-214: Solving linear equations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of Class Activities</td>
<td>Watch videos 211-214 and take notes.</td>
</tr>
<tr>
<td>In-class Activities</td>
<td>Discuss syllabus and course requirements.</td>
</tr>
<tr>
<td></td>
<td>Discuss action research study.</td>
</tr>
<tr>
<td></td>
<td>Complete beginning of semester survey.</td>
</tr>
</tbody>
</table>
### Wednesday, August 27, 2014:

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>511-513: Simplifying exponential expressions using the product rule, quotient rule, and zero exponent property.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Out of Class Activities</strong></td>
<td>Complete homework 211-214.</td>
</tr>
<tr>
<td></td>
<td>Watch videos 511-513 and take notes.</td>
</tr>
<tr>
<td><strong>In-class Activities</strong></td>
<td>Complete informed consent form.</td>
</tr>
<tr>
<td></td>
<td>Video quiz: 211-214.</td>
</tr>
<tr>
<td></td>
<td>POD’s: solving equations with fractions – 2 questions.</td>
</tr>
<tr>
<td></td>
<td>Watch video 511 as a class.</td>
</tr>
<tr>
<td></td>
<td>Questions from homework &amp; videos.</td>
</tr>
<tr>
<td></td>
<td>Notes comparison.</td>
</tr>
<tr>
<td></td>
<td>Example problems.</td>
</tr>
<tr>
<td></td>
<td>3 questions from homework – p.262 7, 23, 33</td>
</tr>
</tbody>
</table>

### Wednesday, September 3, 2014:

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>521-522: Simplifying exponential expressions using the laws of exponents.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Out of Class Activities</strong></td>
<td>Complete homework 514-515.</td>
</tr>
<tr>
<td></td>
<td>Watch videos 521-522 and take notes.</td>
</tr>
<tr>
<td><strong>In-class Activities</strong></td>
<td>POD’s: simplifying expressions raised to the negative nth power – 2 questions.</td>
</tr>
<tr>
<td></td>
<td>Questions from homework &amp; videos.</td>
</tr>
<tr>
<td></td>
<td>Notes comparison.</td>
</tr>
<tr>
<td></td>
<td>Example problems.</td>
</tr>
<tr>
<td></td>
<td>Roundtable exercise – p.268 23, 49, 55</td>
</tr>
<tr>
<td></td>
<td>Quiz 211-214.</td>
</tr>
</tbody>
</table>

### Monday, September 8, 2014:

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>531-532: Define vocabulary associated with polynomials.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Out of Class Activities</strong></td>
<td>Complete homework 523.</td>
</tr>
<tr>
<td></td>
<td>Watch videos 531-532 and take notes.</td>
</tr>
<tr>
<td><strong>In-class Activities</strong></td>
<td>Video quiz.</td>
</tr>
<tr>
<td></td>
<td>POD’s: calculating with scientific notation – 2 questions.</td>
</tr>
<tr>
<td></td>
<td>Questions from homework &amp; videos.</td>
</tr>
<tr>
<td></td>
<td>Notes comparison.</td>
</tr>
<tr>
<td></td>
<td>Example problems.</td>
</tr>
<tr>
<td></td>
<td>Predict 5 quiz questions.</td>
</tr>
<tr>
<td></td>
<td>Complete study guide for week.</td>
</tr>
</tbody>
</table>
Friday, September 12, 2014:

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>541-543: Multiplying two polynomials and squaring binomials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of Class Activities</td>
<td>Complete homework 533-535.</td>
</tr>
<tr>
<td></td>
<td>Watch videos 541-543 and take notes.</td>
</tr>
<tr>
<td>In-class Activities</td>
<td>Video quiz.</td>
</tr>
<tr>
<td></td>
<td>POD’s: simplifying exponential expressions - 2 questions.</td>
</tr>
<tr>
<td></td>
<td>Questions from homework &amp; videos.</td>
</tr>
<tr>
<td></td>
<td>Notes comparison.</td>
</tr>
<tr>
<td></td>
<td>Example problems.</td>
</tr>
<tr>
<td></td>
<td>Ungraded quiz on exponents – 3 questions.</td>
</tr>
<tr>
<td></td>
<td>Error analysis.</td>
</tr>
</tbody>
</table>

Media Selection

After deciding to flip my classroom, I immediately began searching the internet for math videos that were already created. I started my search with two topics in mind: solving linear equations involving fractions and solving absolute value inequalities.

Solving linear equations with fractions is a concept taught in Introductory Algebra and then built upon in Intermediate Algebra. Many times this topic is taught utilizing the idea of multiplication using reciprocals, a method that is problematic when the topic is advanced in Intermediate Algebra to solving rational equations. I introduce linear equations with fractions using a least common multiple (LCM) to clear the fractions because this strategy can be used to solve more advanced topics such as rational equations.

I also searched for videos that focused on solving absolute value inequalities because this topic is difficult and challenging for students. There is a lot of conceptual development that needs to occur prior to introducing the definitions of absolute value inequalities and formulas. This topic includes two different formulas depending on whether the inequality is less than (or less than or equal to) or greater than (or greater
than or equal to) as well as three exceptions to each formula. Due to the complex nature of the topic and necessary conceptual development, I felt it would be an informative topic to decide if the videos would encourage learning and mathematical development.

Once my topics were decided, I examined the Kahn Academy (www.khanacademy.org), YouTube (www.youtube.com), Brightstorm (www.brightstorm.com), and private videos online, which charged a monthly fee to access content. Of the various sources of video’s that were considered, none of them aligned precisely with lessons in my textbook or curriculum. The process of searching for pre-made videos on my topics of interest was time consuming and exhausting. I also feel that requiring students to engage in videos that were created using several different mediums and included different people would be too disjointed for adult developmental learners, a unique population that, in my experience, thrives in consistency and structure.

The videos included with the purchase of a new textbook were also considered. I especially liked how there was a video for each lesson in the text and they were numbered to correspond with the appropriate lesson. However, like all other videos, I felt that the textbook videos were too focused on procedural knowledge and did not include enough conceptual ideas. For instance, when I watched the video on solving equations, the author simply went step by step using the appropriate procedures but never justified why she was doing each step or exploring the meaning of each. In many of the videos, teachable moments were often overlooked.

My exhaustive search of pre-made videos prompted me to create my own videos. Deciding on a media type to utilize for the video lectures has been challenging. I had certain requirements for the media choice I would utilize. I wanted the ability to capture
my handwriting, voice, and electronically typed notes. Based upon those criteria, the Wacom Bamboo Stylus in conjunction with Camtasia Studio 8, software that allows the user to capture voice sounds and record their computer screen, was recommended by the technology and instruction design specialists at my institution. One use later and I quickly decided that the Wacom Bamboo Stylus was not an appropriate tool for me since it had limited space in which to write. Also the writer had to watch the computer screen but write on the Wacom Bamboo pad. The Wacom technology was not mathematics user friendly.

Next, I utilized a laptop from the technology department that included a digitized pen that allowed me to write on the laptop screen. I felt this type of technology was a good resource and would meet my needs well, but the laptop was slow, outdated, and the digitized pen was chunky in its marks on the screen which made for writing complex mathematical notation difficult. For instance, when working with rational exponents it is necessary to write the exponent small and in the upper right hand corner of the base. But, when you are working with fractional exponents \( \left( \frac{3}{4^2} \right) \), it is difficult to write the fractional exponent small enough that it still looks like an exponent and that is legible. If the exponent grows too large then the mathematical interpretation changes and it can begin to look like a mixed number which has an entirely different meaning.

After my difficulties with the outdated laptop, I considered using a video recorder to record me teaching in a classroom at a whiteboard. The video recorder had to be zoomed in close to pick up the handwriting on the whiteboard. With the screen zoomed in appropriately I had little room to work on the whiteboard. This method of video recording also inhibited my ability to use any electronic notes, such as concept maps,
when appropriate. Everything would have had to be handwritten and that could get exhausting.

After much trial and error I ultimately used a SMART podium with interactive pen display that allowed me to capture my handwriting using SMART board software in conjunction with mediasite recorder, which captures and records all sounds and images on the screen, to create a pilot video lesson on rational exponents. The digitized pen allowed me to change the thickness of the pen so that I had the ability to create correct mathematical notation as well as to change colors when I wanted to highlight certain steps or procedures. This lesson was created as a pilot in place of a class that I was missing in the spring 2014 semester due to my attendance at a conference. The only difficulty in using this technology to create my lessons is that the SMART podium is located in our distance education classroom on campus. I must coordinate my use of the room around classes held there and other faculty that are also using the room.

It was finally decided that the technology department would purchase a new tablet PC with a webcam and digitized pen. SMART Notebook collaborative learning software along with Camtasia Studio 8 was installed on the tablet PC. This technology allows me to capture handwriting on the screen, voice recordings, and the freedom to utilize course materials I have developed in Microsoft Word, simultaneously. This technology is mathematically user friendly and is portable so I have the luxury of working whenever and wherever it is convenient for me.

Pilot Video Lesson

I created a pilot video lesson to replace a class that I was cancelling due to conference attendance during the spring 2014 semester. The focus of the video lesson
was understanding and simplifying rational exponents. I felt that there was a learning curve in re-imagining how to teach using a different delivery medium. Since my pilot video lesson was replacing an entire class, I had to design the lesson to be thorough as we would not have the opportunity to engage with the lesson and ideas during class time. In an effort to maintain consistency, I structured the video lesson just like a typical class, the notes were organized in outline form and I began with the definition of a rational exponent and then led into numerous examples. I attempted to keep the pace as comfortable as possible but since there was not a live audience, it was only my best guess. The video also ended up being much longer (15 minutes) than I would have liked since I was presenting the entire lesson as opposed to just background and introductory information. This is an evolutionary process and I am not going to grow and develop in this pursuit while I continue to do it.

Upon my return from the conference, I gave each student a quarter sheet of paper and asked them to put a positive sign on one side and a negative sign on the other. I asked them to write down any positive comments they had regarding the video lesson (rational exponents) for Friday’s class (4/4/14). If they had no positive comments I asked the students to write “none,” which signified to me that they thought about the question. I asked students to do the same thing for the negative side. I also stressed to the students that they should be honest and constructive in their feedback. I assured them that they would not hurt my feelings. I allowed the students ample time to complete the task and did not begin teaching until every student appeared to be finished. I asked the students to pass in their comments and create one pile so that I would not know which student made which comments.
The results of their feedback were overwhelmingly positive. I was quite surprised as I did not think the video was my best work. The positive comments resulted in four primary themes. The first theme described by the students was the ability of them to work at their own pace and not that of their classmates. They also liked the ability to pause and rewind the lesson as necessary to support their learning. One student commented, “I really liked the video because I was able to take my time to understand the process of the new material by using the pause and rewind button.”

Another theme that emerged was that students felt that the video lesson was similar to a typical class. One student noted that, “I thought it was just an ordinary lesson but just not being physically there in class.” Another student said, “The online lesson was conducted just as it would have been if we were in class.” Students seemed to find comfort in the consistency between the video lesson and a typical class.

Students also repeatedly commented on the number of examples that I provided as well as that they were detailed and thorough. One student stated, “Very descriptive step by step process of how to solve these types of problems.” They noted that the examples were fully explained and worked out for them to either complete on their own or to work along with me.

The biggest complaint from the students regarding the video lesson was that the video was of very poor quality. They noted that the video was extremely blurry and hard to read. Since the text was hard to read, students had to wait for me to read the problem before they could write it down or attempt it on their own. Prior to sending the link to the students, I watched the video and I did not have an issue with poor video quality. The technology department explained that the way that the video was embedded within
Mediasite is most likely the cause for the poor quality. I will save and upload all videos to our course management system for the students to utilize.

The other concern that surfaced in their comments was the inability to ask questions if they had any. This problem would be mitigated with the in-class portion of the flipped lesson where background information is introduced and then students arrive in class with any questions they may have prior to processing and application of ideas.

Initial Video Lessons

I began using the tablet PC purchased by the university during summer 2014 to create the video lessons I would need for the first two weeks of the semester. The first video took about thirty minutes to create because I had to keep erasing and re-recording due to mistakes I was making either in my writing or in my verbal explanations. After that first video, I decided to learn how to edit using the Camtasia Studio 8 software. I quickly discovered that editing the video was much easier and less time intensive than re-recording each lesson. There were several lessons that I deleted two or more sections. Throughout the recordings I learned to start making notes of how many places I needed to edit as well as about what time the edit should occur. I decided that in future videos I would create verbal cues such as “begin edit here” and “end edit” to more easily signal the appropriate deletions.

Throughout the creation of the video lessons, I was conscious of time and worked diligently to keep all videos less than seven minutes. I found that to adhere to the brief length I had to break topics into small chunks and plan carefully so that each topic could be introduced and presented within the short time frame. For example, I created five different videos on the topic of solving linear equations. I broke that larger topic into
four smaller ideas along with one video of extra practice solving equations with fractions using a least common multiple because that idea is challenging for students and vital to their future mathematical success.

I created the videos on solving linear equations with the dual purpose of being used in both Introductory and Intermediate Algebra. Students are expected to enter Intermediate Algebra with this skill set already mastered, but unfortunately many do not. Since this is a prerequisite skill, very little time is devoted to teaching the concept in the course curriculum. Solving linear equations is taught in detail in Introductory Algebra. During the video creation I was careful to make sure each aspect of the concept was explained so students with no prior experience could understand them and also so students simply requiring a refresher would gain confidence with the concept.

After I watched each video and determined that they met my expectations, I asked my eleven year old daughter to watch the first two videos. My daughter recently completed fifth grade and has not learned how to solve algebraic equations. She watched each video two times and was able to follow my instruction to complete the examples. Excited with her new skill, she asked for more examples to try. With no further instruction on solving equations beyond my videos, my daughter was able to solve all examples with 100% accuracy. I did give her additional instruction on using signed numbers (adding, subtracting, multiplying, and dividing) because the examples included them and she has no prior experience with positive and negative numbers. My daughter’s successful experience with those videos demonstrated to me that the videos were easily understood and should meet my dual purpose for use in both Introductory and Intermediate Algebra.
I found with some of the other videos I created that they seemed to be very procedural based. Procedural knowledge was a concern of mine with the plethora of videos for use on the internet and one reason why I decided to create my own videos. I am not sure if the procedural aspect was more topic related or my need to create a video designed to teach a skill. It is my intent to remain mindful of this concern and work to mitigate it as I become more experienced at creating video lessons. I did attempt to incorporate as many conceptual ideas as possible into each video.

Although the videos I created are based upon procedures, I was cognizant of the need to explain why for each procedural step as well as to incorporate mathematical concepts supporting those procedures. For example, when solving equations like $3x - 7 = 17$, students I have worked with typically memorize that you add or subtract the number in the second position ($-7$), without ever really understanding why we do that. It is important for students to understand that we would add seven to both sides of the equation because addition is the inverse of subtraction and therefore will eliminate the seven and begin to isolate the variable. Also, because they have simply memorized that process, the students then struggle to solve an equation that is not in that form, i.e. $-7 + 3x = 17$ or $17 = -7 + 3x$. If students resort to their memorized procedures, some students would then subtract $3x$ from both sides in the equation $-7 + 3x = 17$ (which is the same equation as $3x - 7 = 17$) which would not be productive. Within the videos, I gave the students questions to ask to help them see each of the components of the equation as well as understand the meaning of each. Because my students struggle to understand the language of isolate the variable, I asked them “what is attached (by addition, subtraction, multiplication, or division and on the same side of the equals sign) to the variable?” It is
the intention that students would recognize that three and seven are attached to the
table. The next question I posed to the students in the video was, “how are those
numbers attached (addition, subtraction, multiplication, or division) to the variable?”
Students then begin to focus on the interpretation of the mathematical symbols and
understand that three is attached by multiplication and seven by subtraction. The final
question is, “how do we undo each of those operations?” At this point, students I work
with are usually able to determine that the equation is solved by adding seven and then
dividing by three because those are the inverses utilized in that particular equation.

My video lectures were not radically different from the in-class lectures that I
would have normally given. The video lectures that I created had to provide necessary
background knowledge and form a foundation for the mathematical ideas held within the
curriculum. Developmental learners are lacking many basic skills as well as
understandings of foundational mathematical ideas. In some ways the video lectures are
like an in-class lecture: it was necessary for me to provide foundational, conceptual, and
procedural ideas in the video lectures.

My nine years’ experience teaching developmental mathematics informed me that
my students could only handle a finite amount of information in each video. The length
of the videos had to be kept short so students would not lose motivation to participate in
them. It was necessary for me to strike a balance in what was necessary to include and
what could be omitted. Conceptual ideas were included as often as possible.

Participant Selection

This action research study used a purposeful sample of developmental students
enrolled in one of my sections of Intermediate Algebra, the last developmental
mathematics course prior to college level courses. Students either self-selected the course or were placed into the course by academic advisors. Enrollment in this course is capped at 25 students and there were 22 students enrolled for the semester. The course is a mixture of regular admission students and students who enter the university through a state-funded program that recruits educationally and economically disadvantaged students. The students were primarily traditional age students.

Much of the adult education literature defines adult students as those individuals 25 years of age or older who are usually responsible for themselves and sometimes dependent children, are their own financial supporters or have other adult responsibilities (Kasworm, 2003). Merriam, Caffarella, & Baumgartner (2007) state that, “adult education is a large and amorphous field of practice, with no neat boundaries such as age” (p. 53). Adult students learn based upon the effect of life experience influencing current learning and meaning making (Halx, 2010). Traditional undergraduate students also have life experience that informs their learning and too often their life experience is not acknowledged (Halx, 2010). In essence, they “may have more depth of experience to counterbalance the lack of breadth” (p. 520). Life experience should determine whether an individual has reached adulthood as opposed to the individual’s age. An increasing number of traditional undergraduates are assuming more responsibility for themselves and thus becoming more independent (Halx, 2010). Halx also noted that, “life experience, the context of the classroom, and the cultural influences at a given moment all affect the younger learner just as they affect the older learner” (p. 527).

This study was introduced during the first class period of the semester. Students were informed that participation in the study was voluntary and that they could choose to
opt out of the study at any time without fear of consequences to their course grade or treatment within the class. All necessary institutional paperwork, such as IRB approval, was completed prior to the beginning of the semester.

During the first week of classes, a colleague met with all registered learners to determine who was interested in participating in the study. I was not aware of who consented to participate in the study until after course grades were issued. Students were informed of their role in the study as well as their responsibilities.

The beginning of semester survey data revealed that 55% of the population was 18 years old, 35% nineteen years old, and 10% twenty years old. The population consisted of 80% female and 20% male. The ethnic breakdown of the population is as follows: 50% Caucasian, 35% African-American, 5% Hispanic, 5% Hawaiian (Pacific Islander), and 5% Bi-racial.

Data Collection

Data collection consisted of five types of data: researcher journal, surveys/questionnaires, minute papers, interviews, and faculty evaluations. All data collection components are briefly described below.

*Researcher Journal*

Journals and diaries are the major source of data in self-study action research (Herr & Anderson, 2005). Journals:

allow one to express feelings, anxieties, and comments on events that have taken place or that one anticipates. This technique is particularly helpful in action research, because events and activities can change so much during a project that one can easily forget one’s earlier thoughts and feelings. Looking back during the
reflection stage is usually enriched by reflective journals kept by the researcher or
the participants (Kuhne & Quigley, 1997, p. 39).

Keeping a researcher journal provides an opportunity to input my perspective within the
research. A researcher journal is important as it also documents change which enables an
understanding to be created that motivates change in the research within the context
under study (Herr & Anderson, 2005). Since I studied the flipped classroom in my own
practice, a reflective journal was necessary (Herr & Anderson, 2005) to document
progress (Kuhne & Quigley, 1997).

I kept a researcher journal in which I wrote after each class throughout the
semester. Kincheloe (1991) recommends using the following prompt when writing in a
journal, such as: “What were the most significant events of the day?” (p. 107). Other
prompts, as mentioned in Angelo & Cross (1993), can elicit data regarding learning
within the classroom such as, “What is helping students learn? What is making learning
more difficult? What specific, practical steps could he [teacher] and the class take to
improve learning?” (p. 340). The researcher journal reflected my decisions, thoughts,
feelings, impressions, etc. (Herr & Anderson, 2005). I focused my journal responses on
teaching activities and how they changed throughout the semester and I documented what
worked well and what was not successful. I detailed challenges and how I mitigated
those challenges as well as celebrated successes and took care to document teaching and
learning tasks for each class.

Surveys/Questionnaires

During the second class I administered a beginning of the semester survey
(Appendix C). The survey collected demographic information as well as student
responses to three open-ended questions to learn about the students’ attitudes and perspectives related to learning mathematics (Appendix C).

Another survey (Appendix E) was administered during weeks four and ten of the semester. There were eight Likert scale questions that focused on the quality of the video lessons and the in-class activities. There were also two open-ended questions concerning changes for the video lessons and in-class activities as well as an additional question for general questions and/or comments. The purpose of the survey was to elicit the adult developmental students’ experience in the course so far and what changes they would suggest.

**Minute Papers**

Minute papers are efficient as they “provide manageable amounts of timely and useful feedback for a minimal investment of time and energy” (Angelo & Cross, 1993, p.148). As recommended by Angelo and Cross (1993) in their book, Classroom assessment techniques (CATs): A handbook for college teachers, minute papers are generally used to assess student learning for the lesson objective. However, minute papers can also be utilized for immediate feedback for in-class learning activities or suggestions for course improvement.

Students were given quarter sheets of paper at the beginning of one class and asked to write down any questions they still had regarding factoring trinomials after watching the video lectures. Since I was able to read and analyze their responses quickly, I attempted to address their questions during class that same day.

Minute papers were used one additional time to seek student feedback between the weeks four and ten surveys. Students again were given quarter sheets of paper. They
were instructed to write “What needs changed. . .” on one side of the paper and “What is working. . .” on the other. Student responses were analyzed and changes were made to the course based upon student input.

Semi-structured Interviews

Semi-structured interviews, “involves asking more open-ended questions of several participants but allows the interviewee to go further than the precise question with opinions, thoughts, and questions” (Kuhne & Quigley, 1997, p. 40). The purpose of the interviews was to develop an understanding of the teaching and learning environment from the perspective of a developmental math student. Data gathered from the interviews allowed the researcher to acquire information that may not have emerged from questionnaires or journals (Patton, 2002). According to Patton (2002), “open-ended interviews add depth, detail, and meaning at a very personal level of experience” (p. 17).

Semi-structured interviews were selected due to their ability to be developed in advance and to ensure that all participants are addressing the same questions but at the same time permit the participants the freedom to respond to interview questions based upon their perspective (Patton, 2002). Although unstructured interviews would encourage a more conversational atmosphere, there would not be the same consistency between questions with each participant as the questions are developed during the interview (Patton, 2002). Structured interviews would encourage consistency between all questions and responses, but they would not allow for the participants to input their “rich, thick descriptions” (Bloomberg & Volpe, 2008, p. 82).

The semi-structured open-ended interviews (Appendix F) were scheduled with 8 participants during the last week of the semester. Two weeks prior to the interviews,
students were given a piece of paper and asked who was willing to participate in approximately one hour interviews. Students were instructed to write “yes, willing to be interviewed,” or “no, not willing to be interviewed” on a piece of paper along with their name. Of the 17 students in attendance, 12 students said they would be willing to be interviewed. A purposeful sample of eight students was chosen from the pool of 12 students.

During the interviews I kept notes of student responses in an effort to ask any necessary follow up questions. Interviewees were given a copy of all questions at the beginning of the interview (Appendix F). Interviews were scheduled for one hour or less and were conducted once. The audio tapes were transcribed.

Faculty Evaluations

University designed faculty evaluations were administered during the last week of classes. Faculty evaluations (Appendix G) focus on four themes: student’s motivation to take the course, the frequency that the instructor used specific teaching procedures, how the course has helped the student progress in certain areas, and rating of the course and the instructor. Students complete the faculty evaluation using a five point Likert scale. Survey data includes the number of students that did not respond to each question. Basic statistical analyses with percentages were calculated in each of the 17 criteria.

Data Analysis

This study included the four stages of action research: planning, acting, observing, and reflection (Kuhne & Quigley, 1997). During the observation and reflection phases, the various sources of data: surveys, interviews, and researcher journal were analyzed. It was imperative that data analysis was ongoing and coinciding with the action and
observation stages as action research enables the researcher to immediately apply their findings to improve the situation (Merriam & Simpson, 2000).

Data analysis of all qualitative data focused on providing “thick, rich description” (Patton, 2002, p.437). This thick description allowed the reader to “understand the phenomenon studied and draw [their] own interpretations about meaning and significance” (p.438). The analysis extended further by using inductive analysis and working towards the identification of common themes and patterns among the data (Patton, 2002). Data that did not align within the developed categories was examined further. The theoretical frameworks, constructivism and community of math inquiry, were layered on top of the themes and patterns developed from the data to allow for deeper understanding.

Surveys were administered at two points during the study. The beginning of the semester survey collected primarily descriptive data about the participants and was analyzed using quantitative methods. That survey also included three open-ended questions that focused on participants’ perceptions of mathematics and learning mathematics. Participant responses to the open-ended questions were analyzed for common themes and developing patterns. Open-ended questions and interview responses were analyzed using cross-case analysis by “grouping together answers from different [participants] to common questions” (Patton, 2002, p.440).

The researcher journal was analyzed throughout the study. As the researcher I have the responsibility to accurately portray the learning and environment. I worked diligently to understand meanings and not to make assumptions of the data. Content analysis was utilized to filter and analyze the data for themes and categories (Patton,
All data was kept intact throughout the analysis so each piece could be understood. I attempted to be thorough throughout the analysis and document emerging themes.

Trustworthiness of the Study

As with any research, high standards and rigor must be maintained in an effort to judge the quality of work. Qualitative research is concerned with the trustworthiness of the study. According to Patton (2002) and Bloomberg and Volpe (2008), quality in qualitative research is measured by credibility, dependability, and transferability. These measures of quality are discussed in the following sections in relation to this action research study.

Credibility

Credibility refers to the attention paid to fieldwork and other details of the study to ensure quality data was collected and analyzed (Patton, 2002). More specifically, credibility “suggests whether the findings are accurate and credible from the standpoint of the researcher, the participants, and the reader” (Bloomberg & Volpe, 2008, p. 86). Throughout the data analysis, I examined the data for how well the findings and the interpretation of those findings captured the essence of the research purpose, participant’s perspective, and my own perspective as a participant-researcher (Bloomberg & Volpe, 2008; Patton, 2002).

This study generated truth, although truth in qualitative research is not absolute and generalizable as it often is in quantitative. In qualitative research, “truth... means reasonably accurate and believable data rather than data that are true in some absolute sense” (Patton, 2002, p.578). Truth and findings in this study will be created in a
particular setting based upon social and contextual influences specific to that environment. Constructivism guided the creation of truth in this action research study. I was careful not to presuppose findings or assume that I knew what would occur during the data analysis, and I allowed the results to emerge from the data. Discussion with colleagues and my dissertation advisor enabled me to treat the data with respect and not presuppose findings. The reflective journal that I kept throughout the semester helped me to remain true to the data and also helped triangulate the data.

A technique for promoting creditability is triangulation which strengthens a study by combining methods (Patton, 2002). According to Patton (2002), triangulation allows the data to be verified through various sources to determine if a specific theme or result is present. This action research study utilized data triangulation to ensure that the different data sources were consistent. Triangulation of qualitative data sources is about comparing the data sources with each other (Patton, 2002). Triangulation is not to ensure that the different data sources lead to the same results, but that the researcher can test consistency between the data sources (Patton, 2002). For this study, I collected various forms of data such as: researcher journal, open response questionnaires, surveys, and participant interviews. Although the data may reveal inconsistencies, it does not necessarily weaken the credibility; it may mean that different types of data illuminated different perspectives. Credibility is strengthened when the researcher develops an understanding of the inconsistencies and presents a plausible argument regarding the inconsistencies (Bloomberg & Volpe, 2008; Patton, 2002).

Another strategy to enhance credibility is to acknowledge my bias and assumptions. Although bias can occur in qualitative research, it should not infiltrate the
data to the point that it hijacks the analysis (Patton, 2002). Prior to data collection, I disclosed my bias and assumptions to the participants (Bloomberg & Volpe, 2008). I openly discussed my bias and assumptions with my advisor and colleagues thereby creating a personal awareness of those assumptions and attempted to negate the impact of my bias. I also worked to confront any bias and assumptions by reading and discussing excerpts of my journal with the students. Kincheloe (1991) encourages researchers to share portions of their journal with the students as sort of a member check with the students.

Dependability

Dependability ensures that the researcher is “consistent and dependable with the data collected” (Bloomberg & Volpe, 2008, p. 86). Researchers support dependability when they examine the data for consistency between emerging themes. The object is not to eliminate any inconsistencies in the research, but rather to acknowledge them (Bloomberg & Volpe, 2008). Those inconsistencies could be illuminating an aspect that has been overlooked or unexpected but demands examination within the scope of the study.

Dependable studies accurately document and record data collection procedures, methods, categories, and developing themes (Bloomberg & Volpe, 2008). The audit trail discloses the process the researcher used to collect and analyze data as well as the researcher’s thinking and rationale and also why certain themes were created as well as other study related decisions (Bloomberg & Volpe, 2008). Patton (2002) referred to documentation of researcher thoughts and analysis as “intellectual integrity” (p. 553).
The type of audit trail described above creates transparency in the research which supports transferability.

Transferability

Transferability is concerned with the possibility of other researchers and practitioners utilizing portions of this study within their own practice (Bloomberg & Volpe, 2008) or potentially transferring the findings to their own educational setting. Patton (2002) suggests that rather than generalizability, individuals should think in terms of transferability. An important aspect of qualitative research is that it is tied to a specific context and that it is vital to keep all data associated with the context in the study (Patton, 2002). Attempts to over-generalize findings should be discouraged (Patton, 2002). Findings from this study are not generalizable to the larger population of all developmental mathematics instructors and classrooms.

In an effort to support transferability, the appendix contains supporting materials and documents that were utilized in the study. The reader determines what aspects of this particular study with its very specific context could be applied to their classroom or similar situations (Bloomberg & Volpe, 2008; Patton, 2002). Because the purpose was to explore a flipped classroom in developmental mathematics, truth in this context is what is useful to me and others; what is transferable (Patton, 2002).

Summary

This chapter provided background information regarding the research methodology. Qualitative research was selected for its focus on depth of information and understanding related to the research problem. Furthermore, since the purpose of the study was to explore a flipped classroom in developmental mathematics, action research
was the most suitable research methodology. Chapter three also provided information on
the background of the researcher, setting of the study, planned course structure, media
selection, video lessons, and participant selection. Data collection consisted of surveys,
journals, interviews and faculty evaluations. The chapter concluded with trustworthiness
of the study with evidence regarding credibility, dependability, and transferability.
CHAPTER 4

FINDINGS

The purpose of this action research study was to explore a constructivist, flipped classroom with respect to a developmental mathematics classroom. This study was set in a centralized department of developmental instruction in a public, four-year institution in the northeastern United States. The study occurred throughout fall 2014 semester in Intermediate Algebra, the second and final developmental course in the department. The study was guided by the following research questions:

1. How can a flipped classroom be successfully implemented within a developmental classroom?

2. How does a flipped classroom, from the perceptions of adult developmental learners, promote a community of math inquiry in a developmental mathematics classroom?

3. What are the perceptions of adult developmental learners concerning the flipped classroom and the impact on learning for developmental mathematics?

4. What practical strategies were most effective at facilitating a flipped classroom from the students’ and faculty member’s perspective?

5. What is the degree of satisfaction of the flipped classroom from the student’s perspective?

Beginning of the Semester Challenges

Transitioning from a teacher using traditional whole class lectures into a facilitator in a flipped classroom posed numerous challenges during the first week. My ignorance and naiveté with flipped classroom teaching inhibited me from anticipating
some beginning of the semester challenges. My first journal entry for the fall semester discussed an early challenge with creating the video lectures. I wrote,

I created three videos for lessons 511 – 513 [simplifying exponential expressions using the laws of exponents]. I worked hard at trying to break the topic down the best that I could. I kept each video to seven minutes or less. It took a long time to make each seven minute video. I estimate that a seven minute video took 30 – 40 minutes to produce. I was a little rusty when I started with the first video [I hadn’t produced a video in several weeks at this point] and needed to acclimate myself to teaching with this medium and develop my comfort level. Once finished recording the video lecture, I would have to watch the video to edit out my mistakes. I started saying “delete” repeatedly to ease my editing issues by helping me to identify the portions to delete. (August 27, 2014)

Since I was trying to keep the video lectures short to keep the adult developmental students engaged, I found it a struggle to determine what was absolutely necessary in each lesson, which is why I had to “acclimate myself to teaching with this medium and develop my comfort level.” I also had the challenge of teaching to a computer screen and empty room which was a new experience for me.

Prior to posting the video lectures that were just created, I made the assumption that I would need to teach the adult developmental students how to engage with them. The second day of class I elected to use class time to show the students videos 511 and 513. I wrote in my journal,

I used the remainder of class time [after obtaining informed consent] to watch two of the videos with the class. I paused the videos at various points whenever I felt
that the video instruction was too fast for them or when they should complete a problem first and then check with my work. I tried to teach the students how to interact and engage with the videos. I had difficulty reading the class’ reaction to the videos. The students were almost indifferent in their body language and behavior. I am going to assume that it wasn’t a total failure or a total success. I passed out my concept map on exponents to the students at the start of the video lessons so they could take notes directly on that paper. Although the videos were seven minutes or less it took approximately 20 minutes to show both videos with the stopping and starting and the discussion I attempted to elicit from the students.

(August 27, 2014)

I underestimated how long it would take to show a seven minute video lecture and used much more class time than I would have liked. It was my intention that by modeling the engagement with the video lectures, that it would help the adult developmental students understand what was going to be expected from them throughout the semester.

Another struggle that I experienced dealt with the ability of students to access the videos through our online course management system. I noted,

After I started uploading the first videos a few students started emailing me stating that they were having trouble opening and viewing the videos. After speaking with our technology department I was informed that the student’s technology requires them to use a video player that will play mp4 files. I started emailing each class [I uploaded the videos to both my flipped class and my traditionally taught classes] with some basic directions. I did not receive any
more student emails or questions expressing concerns opening and engaging in
the video lectures after sending the email. (August 27, 2014)

My ignorance did not plan for technology issues with opening the video files. Although
the technology issues were short lived they did pose initial frustrations with the students
and me.

The next struggle that I experienced was with checking the student’s notes to
ensure they were watching the video lectures. After showing videos 511 and 513 in
class, I expected the students to watch videos 521 and 522 for the next flipped class on
Wednesday, September 3, 2014. I wrote the following in my journal,

I began class with a short five question quiz that was open notes.

    Video Quiz 521 & 522

    Use your notes to answer the following questions (2 pts. each)

    1.) What was the objective in lesson 521?

    2.) Write the problem given for example #1 in section 521.

    3.) Write the answer for example #2 in section 521.

    4.) Write the answer for example #1 in section 522.

    5.) Write the answer for example #2 in section 522.

The objective of the quiz was to determine who watched and engaged with the
assigned video lessons. The open note quiz took much longer than I would have
liked. We lost about 8 minutes of class on the open note quiz. I did not like it
because I felt it was an ineffective use of class time that was not extending any of
the learning. For the next flipped class I will simply check each student’s notes as
I circulate throughout the room during class. I can glance at a student’s notes and
tell whether or not they engaged with the videos. From now on, I am going to do a note check and count it as 10 participation points each time so it is equivalent to a homework assignment.

Since I was conducting an action research study where the researcher has the ability to change things to better meet the needs of the participants and researcher, I changed from quizzes on the video lectures to a simple note check done by me during the in-class learning activities. Several days later I noted in my journal,

I like visually checking their notes as opposed to an open note quiz. My checking is quicker and more efficient than a quiz. I am able to check notes at the same time I am checking in on each group for any questions. (September 8, 2014)

I continued to visually check their notes throughout the rest of the semester. Each notes check on the videos was considered a homework assignment and included in that portion of their grade. Although challenging, I was able to work through each of the struggles I experienced at the beginning of the semester.

Key Findings

This action research study is organized around qualitative and quantitative findings from the following data sources: beginning of semester questionnaire, weeks four and ten surveys, minute papers, researcher journal, end of semester interviews, and faculty evaluations.

Qualitative Findings

Analysis of the qualitative data revealed seven themes: beliefs about math, ongoing transformations, shared connections, enhanced independence, learning through the video lectures, community of math inquiry, and the way I teach. The data presented
in the following sections emerged from the beginning of the semester questionnaire, end of semester interviews, and researcher journal. Each of the themes will be developed and discussed below.

Beliefs about Math

The beginning of the semester questionnaire administered on the second day of class illustrated the adult developmental student’s initial beliefs about mathematics. Based on the analysis of the open-ended questions, when students hear the word mathematics, they often think of struggle and frustration.

Mathematics as a struggle. One-fourth of the adult developmental students responding to the beginning of semester survey commented on their personal struggle with mathematics. For example, Ava said, “When I hear the word mathematics I think about numbers and variables or something that I am not quite good at.” Similarly, Sara commented,

Mathematics means a class I have always struggled with. It was always dreadful for me because it’s the only subject I’ve ever had problems with. The word mathematics brings up a lot of memories of homework problems I didn’t understand and staring blankly at equations on a board.

Allison was another student that noted her struggle with mathematics when she stated, “When I hear the word mathematics comes to mind I have a miniature panic attack because math was never my strong point and I always struggled with it.” Kayla also commented that mathematics makes her think of “equations that I don’t know how to do and struggle with.” Taya affirms her classmate’s attitudes because she said, “When I
hear the word mathematics, I think of numbers. I also think of how much I struggle with
math.”

**Mathematics as frustration.** In addition to their struggle with mathematics, adult
developmental students were frustrated when learning mathematics. For instance, Jason
stated that he felt, “Discomfort, and lack of confidence. All through high school math
was NOT my strongest subject, it is a subject I get frustrated with!” Similarly, Kelly
noted, “When I hear the word mathematics, I automatically get annoyed and frustrated.
Math is not my strong point at all.” Megan’s frustration also included fear when she said,
“When I hear the word mathematics a bunch of hard unanswerable questions comes to
mind. With the word mathematics brings fear and a certain unsureness about the answers
I give.” Paige’s opinion was also very strong when she said, “I am horrible at math! I
have no successes. I’ve always have been a C- student in math.” Another student, John,
stated, “I have a rough history with math. I always had trouble understanding it,
especially in high school.” Both John and Paige are clearly frustrated in their attempts to
learn math.

The comments above illustrate the fact that these adult developmental students
feel defeated by mathematics. It was only the second day of class, but several students
noted their “struggle” with the subject. Student comments alluded to a long, difficult
history with mathematics when they said that it “was never my strong point,” “how much
I struggle with math,” “a class I have always struggled with,” and “all through high
school”. One student even noted the intense physical distress when she noted that she has
“a miniature panic attack.” It is apparent that these adult developmental students
possessed strong, negative feelings and attitudes towards mathematics at the beginning of the semester.

**Ongoing Transformations**

Interview data revealed that the adult developmental students’ perspectives about mathematics were evolving and changing over the course of the semester. The majority of students seemed to experience shifts in their attitudes and mindset regarding mathematics, where they felt more positive about math and learning math. This section will address the adult developmental students’ emerging change in perception, how they went from hating math to liking math, their increased confidence, and their greater enjoyment of mathematics.

*Emerging change in perception.* The flipped classroom appears to have been a catalyst for changing the adult developmental students’ opinions regarding mathematics. The beginning of semester questionnaire demonstrated that students struggled with and feared mathematics. However, as the semester quickly progressed, the classroom was altering their preconceived notions about mathematics. I noted within my researcher journal on two different occasions that student perceptions regarding learning mathematics seemed to be changing and very early in the semester. In fact, the following excerpt was taken from my journal on the same day that I administered the initial survey. I wrote in my field notes,

> I decided that I wanted to do it [administer the initial survey] today because I was afraid that too much longer and I would begin to alter their perceptions about learning mathematics. During the first two days of classes I had several students stay after class to speak with me. One of the students stated that they feel hopeful
and like the way I have set the course up. They feel that I am setting them up for success. Already, their perceptions are changing.

An example [from an interaction with a student] to illustrate this point concerns one student in particular. Sara was absent the first day of class due to an illness. I had already uploaded all course documents (syllabus, course calendar, binder instructions, videos for the first day of class, etc.) to BOLT. Sara took the initiative to go into BOLT and download and print all course documents as well as engage in each of the videos I had uploaded on solving equations. She stayed after class on Wed. to ask me if she needed to do anything else. She also showed me her notes. It was obvious that Sara engaged in the videos based upon the notes that she took. Her notes looked like she was in class. Sara proceeded to say to me that she felt that she was in class that day even though she wasn’t. She also stated that she felt like she understood for the first time in a long time. (August 27, 2014)

Based upon conversations and interactions I had with the students, I felt that I was observing some initial perception changes.

Another entry from my journal about 4 weeks later focused on how one student was beginning to see that perhaps he can learn math:

What also impressed me today was one of my male students who has struggled from day one and told me early in the semester how difficult it is to learn math, took the initiative to put one problem on the board and explain why it was impossible. I was thrilled and felt like we climbed a mountain together. He is
beginning to see that he can learn math if he invests the effort. It is quite rewarding. (September 29, 2014)

That male student mentioned above was brave. A mathematics classroom is an extremely scary environment for those students who struggle mathematically. Yet this student found the courage to not only put a problem on the board but also explained it to the class. His courage and confidence in that situation are indicators of his changing perception regarding mathematics.

The adult developmental students also spoke of how their perceptions were changing during the end of semester interviews. Ava commented,

I’m not as skeptical about math anymore. I’m not going to push away from it. I was afraid because I knew you have to take math in college, especially for certain majors and I was like – I don’t know how I am going to pass in college in any math class if I don’t know how to do anything. Now I am more open-minded to math and more open to wanting to take a math class. I actually schedule[d] a statistics class for next semester. I would’ve never done that. I would’ve never done that.

Ava’s enthusiasm for her next math class is characteristic of several other adult developmental students who were motivated to advance their mathematical knowledge. Jasmine stated,

Since I went through Intro and Intermediate, now I feel like I am going to go to College Algebra and keep goin’ and keep goin’. I’m not gonna stop like everybody else. I’m gonna keep doing math. It is expanding my mathematician-ness. Is that a word? It’s expanding me.
All students noted in their interview that they were looking forward to their math class next semester. Allison stated, “I absolutely would never mind taking another math class again.” Sara commented in her interview that she is taking three math classes next semester. In preparation for that, Sara explained that she downloaded all of the videos that I produced and is saving them to assist her the following semester.

*Hating to liking math.* The end of semester interviews demonstrated that six of the eight adult developmental students went from hating math to liking it over the course of the semester. Ava noted in her interview,

I was nervous at first because I was just thinking to myself “I have never been good at math and I have to be able to understand this concept just through a video.” But, I actually liked it a lot more because I’m looking at how you are showing me how to do it and I’m taking a moment seeing okay -- I am able to do this myself and to go back and see if I’ve messed anything up or where I went wrong or if I did it right.

She also noted,

I actually liked learning math this year. Like I’ve always been like the type of person if I don’t like something or I’m not good at it, I just shut down. But if I understand something from the beginning then I am more motivated and into learning more about the topic. This semester actually felt like I understood math for the first time.

The participants were beginning to state how strongly they felt towards the flipped classroom and how it has changed their perceptions of learning mathematics. This change was evident in the interviews. Sara stated,
I don’t want to go back to a traditional classroom. I know I’m going to have to, but I don’t want to. I just have grown so much because of this class. It’s really changed the way I think about math and it’s just been so helpful. It has changed my perception of learning mathematics because I just – I know it’s possible now, like before I thought I was always going to suck at math. I always thought that I was never going to get better at it and I was always going to hate it, and that I would never be able to learn it on my own – like I did with other classes. I sat in traditional classrooms for 12 years not understanding what I was doing. As soon as you flipped the classroom, it just took you trying something new.

Allison was another student whose attitude regarding mathematics had changed over the course of the semester. She stated:

I always just hated it [mathematics] all throughout high school, I absolutely hated it, regretted taking any math classes. I almost failed out of all them except geometry. And I was just so terrible at it. Honestly, in the beginning of the semester, I was nervous. I don’t know if I am going to like this. It’s [the flipped classroom] the only way of learning math that has worked for me thus far. Before this, I would have never been able to just learn all of this math. I was very negative towards it. It [the flipped classroom] changed my mind about it [learning math].

Jason’s comments illustrates his transition from hating math to liking it when he said,

Math used to be this overwhelming thing and I would have homework, and I wouldn’t even know how to do it, and so I usually wouldn’t even do it. And it’s
changed that I can now understand it, and I have the confidence to go and it’s something that I enjoy versus something that I used to hate.

During the interview Emma expressed that she struggled with mathematics and did not like it because,

I was always like told when I was little that I was never supposed to be good in math because I was a girl, because of the school that I went to. I went to a Catholic school and I had the same math teacher for six years and he would always like not help us.

Later, when asked how the flipped classroom has changed or not changed her perception of learning math, Emma noted, “I like math. I like learning math.” Kristin was one of the students whose attitude did not change because she noted, “Math is my favorite subject so I like learning it.” Jasmine also entered the class already liking math. She stated,

When I was in high school I really liked math. Math was my favorite subject, but then I got to college, you know my freshmen year, math was easy. I got like a B. But then Intermediate was starting to get a little harder and I was like, “Whoa, I am not use to this math right here,” but I still liked math though.

Both Kristin and Jasmine differed from the other adult developmental students as they already liked learning mathematics.

*Increased confidence.* The flipped classroom had a direct affect on the adult developmental students’ level of confidence concerning learning math. Allison made the following comments,
I think every single math class that has ever came to be should be a flipped classroom. Because if I had this throughout high school, I would probably be a mathematician by now. I told my mom this, “I’m gonna be a mathematician someday.” If I learn this way in every other class I would be a 4.0 straight A student.

It is readily apparent that Allison’s confidence has improved significantly based upon her comment, “I’m gonna be a mathematician someday.” In the beginning of semester questionnaire, Allison is the student that commented, “When the word mathematics comes to mind I have a miniature panic attack because math was never my strong point and I always struggled with it.” To effect such a change in a student is significant. She now feels very strongly about her ability to learn mathematics.

Similarly, Jason’s interview response also demonstrates an increase in his confidence mathematically. He said,

It definitely helped [the flipped classroom]. It helped because it showed me that I could do math and that I could understand it. Yea [it was empowering] because math always used to be such a struggle when I didn’t get it and I would just give up. But, now, like this has helped me understand and like, given me the confidence that I can do it if I pay attention and take the time.

Ava also alluded to her increased confidence in her response,

In the beginning when we worked in the groups, I was a little skeptical about it just because in my math classes I was always in honors math. I was with a whole bunch of smart people. I was kind of challenging myself. I always felt like the stupid one in the group, so I always tried to…In math class, I tended to go from
being open and saying I know things about a problem to kind of being closed off and not saying anything. That’s how I came into this course. I am just going to kinda sit back and see how this goes and how I start to feel and get everything flowing in my head about math. Once I got comfortable with it, I was more comfortable to talk to my peers about it because I was like – okay, I know how to do this; so if you don’t, I can help you. And then, I was not afraid to ask “How did you get that?”

At this point, Ava feels comfortable enough to help others with their math because she is confident in her abilities. She also indicated some degree of self-empowerment as she was unafraid and not intimidated to ask her peers, “How did you get that?” This demonstrates Ava’s confidence that she built as she transitioned from being a silent student who felt stupid and intimidated within a group setting to a student who was not afraid to ask her peers how they arrived at an answer that may have differed from her own.

*Greater enjoyment.* The flipped classroom not only assisted the students in developing their confidence, but they also found the class to be a source of pleasure as they developed gratification from their grades and understanding of course content. Allison stated,

Math class is my favorite to go to. It’s not something that I would typically love to go to at 10 in the morning but when its math day, I don’t mind getting up and going to math class. Just because I know that I am actually going to be learning and I am going to be satisfied.

Jason also commented on his enjoyment of the flipped math classroom,
I loved it. Honestly, it was great. I liked coming into the class already knowing what we were going to be doing that class, and then working in groups. Like I said, I really really enjoy it. I think it is really beneficial. It really helped me to understand. I enjoyed it because I understood.

This seems to be the pattern for several of the adult developmental students; they found enjoyment within the class because they felt like they understood the mathematics.

Sara’s comment supports the enjoyment as a result of understanding when she noted, “Like I have said, it has really worked for me. I love being able to pause the videos and do what I need to understand it on my own terms.”

The grades the students were earning were another contributing factor to their confidence and enjoyment. Sara noted,

I think when I – Ok – one of the turning points would have been when I got my midterm grade back. When I told my accountant mother that I had a 96 in math, she was so happy, and I was so happy.

Sara went on to say that, “Having a high grade and knowing I earned it has really boosted my confidence and helped me.” Allison made a similar statement when she said, “My grade just makes me happy.” The student’s grade made them feel good about themselves and their learning. It seems that they really know that they have learned math when they earn the grade.

Students noted on the beginning of semester survey that they have typically struggled for so long to learn mathematics that many of them begin the course with very little motivation. Learning mathematics has been a constant battle for them. Their previous lack of success reinforces to them that they cannot learn mathematics and many
simply do not even invest the effort. However, the flipped classroom altered these students’ perceptions of mathematics and their ability to learn it. Slowly, over the course of the semester, students began to realize that they could learn mathematics and their grades demonstrated that they could do it. Once their perceptions began to change it was almost like their thoughts and understandings about themselves as learners of mathematics solidified to the point that it became an unchangeable absolute. It is like the adult developmental students became empowered and confident in their ability as mathematical learners.

*Shared Connections*

The flipped classroom helped the adult developmental students feel connected to their fellow classmates and establish a comfort level with their peers. The students were able to quickly develop relationships with each other through their shared struggles and experiences. They felt connected with their peers and cultivated friendships. Allison’s comment, “We just all really formed a relationship. I think it’s because we all hated math.” provides insight as to how the shared connections began to develop. She went on to say, “I could share how I felt with the other kids, and how they hated it.” Allison also noted,

We were just put together and we ended up really liking each other. I think that’s like really important, especially for things that were stressful like math. To have a relationship kinda like trust that person – have – know that they understand how you are feeling. Just have them there to support you kind of.
Allison’s comments demonstrate that she felt comfortable within the classroom because she felt understood by her peer group. Ava also noted how she shared connections with her peers when she said,

I felt that because everyone is a little scared and not really good at math, everyone was comfortable with each other. We all have something in common. We all struggle with math. It was easier to relate to each other, easier to talk to each other about math. It was more of a comfort level. There wasn’t anyone in the room that was a math major or a genius at math. We all had this little bit of like – I’m not sure. It was not a very intimidating environment.

Ava’s relationships grew from the common struggle she noticed that they all seemed to share regarding learning mathematics. Similarly, Paige noted that she too developed relationships and became comfortable in the classroom when she said,

I think it’s different in that kind of classroom, because we are all kind of used to each other kind of. I think it’s better, like in the beginning of the year to get everyone friendly with each other and you know and have groups and everything, because then people are more in to talking out loud and more. . . I think we become more comfortable.

Paige was able to develop relationships and become comfortable within the classroom through the daily work with her group as well as the ability to “talk out loud.” She also noted,

Whenever you are with your friends, I think you get off topic, but whenever you are with your friends you are not as uncomfortable than with other people and like you actually – you’re like, “I know I sound dumb but let me ask this question.”
Paige’s comment above illustrates how comfortable she became in the classroom when she referred to her “friends” and how she felt connected with those classmates through that friendly relationship. She was also comfortable enough to ask questions that could be perceived as dumb by her peer group.

Similarly, Emma’s shared connections have led to her and her group becoming social outside the classroom. She noted,

We’ve become friends and I like that because, walking in there [the classroom], I was like “Oh, I’m not going to know anybody.” Now we are really good friends and we are going to hang – and see each other in other classes and that was really awesome.

Emma found comfort in feeling connected to her group and is looking forward to continuing the relationships beyond this classroom. I, too, noted the comfort level of the students within my journal about one month into the study. Before starting the lesson for that day,

I asked students to recall the characteristics for the method of factoring today: sum and difference of cubes. Students reviewed their notes and were calling out different characteristics. Students were not shy and easily volunteered answers. They seem very comfortable with each other and as a class. (October 1, 2014)

Another journal entry highlighted the comfort level and connections that were developing when I noted,

I have been noticing that the environment in this classroom is extremely comfortable. Not only are the students appearing comfortable with each other but with me also. Most of my classes are comfortable (for the most part) but
sometimes I am unable to connect will all students. I feel like I am really getting to know these students. I also feel like the learning environment is shifting in its power dynamics. Although I will always have perceived power, the students are feeling more empowered and motivated, at least in the classroom. One student was comfortable enough to ask if they could use their brain dump papers [they are only permitted on exams] for Monday’s quiz on factoring. I was flattered that she wasn’t threatened and was willing to ask. I compromised and am allowing them to use a 3x3 post-it note for their brain dump [on the quiz] (October 3, 2014).

It was evident to me as the teacher researcher that students had become comfortable in the classroom. A different journal entry one week later stated, “I am noticing that many of the students seem to know each other’s names and have developed a comfort level with the majority of the class. I enjoy watching them work together” (October 8, 2014). Learners that are uncomfortable would not take the time to learn the names of their peers within the classroom.

The connections that the students built with each other and me helped to create a comfortable and dynamic learning environment. About halfway through the study I made an entry in my journal regarding the Problem of the Day (POD). I noted:

There were two questions related to the POD’s today. When the questions come in, I always re-direct back to the class to get the students doing the talking. They are very comfortable explaining in this way. I only jump in to help or clarify. I do enjoy how they answer each other’s questions. (November 12, 2014)

Students lacking a relationship or comfort level do not usually have the confidence to publicly answer a question addressed to the classroom teacher.
Enhanced Independence

Enhancing their independence was important to the learners in the flipped classroom. They did not want to rely on the instructor for all of their learning. The students wanted to come to understand the mathematics for themselves and learn from their peers. Students craved the ability to learn mathematics with less input and support from their instructor. For example, Jasmine stated that she likes the flipped classroom “because you learn it yourself. You are building your own knowledge up also with the teacher’s help but also seeing if you can do it on your own without always depending on the teacher to help you learn.” Sara was similarly surprised when she realized that she was becoming an independent learner with mathematics. She said,

But, if we don’t [need help] we are kind of on our own and it’s nice to know that we can be independent with our math. Because that’s something I never would have seen myself doing, like learning math independently or with a small group. Like I never would have imagined myself doing that.

Sara’s new found independence with learning math was a turning point for her in her journey from pure hatred to enjoyment of the class. She stated, “Another point was when I realized that I could learn it on my own, without needed to ask a ton of questions. I could figure it out for myself. That really helped me.” She went on to say,

So, I had two years of algebra before now, and I hated it. But now that I am teaching myself a little bit, it’s just rewarding to know that I am actually learning. I never knew if I was actually learning in high school and now I know that I am. I loved the feeling that I’m learning on my own and I am doing really, really well. It’s not all based on just, you [the teacher]. It’s not just you [the teacher]. Like
I’m teaching myself and that just makes me feel so good. That just really helps me motivate myself.

Sara’s comment, “It’s not just you [the teacher]” shows that she felt that her success and previous learning was dependent on her teachers. Her comment above illustrates how she felt she was teaching herself and how that was a motivator for her. Sara gained freedom from the instructor and noticed that she was able to learn math herself.

Both Jasmine and Emma explained that with the flipped classroom and their ability to learn on their own that students cannot blame their lack of success on the teacher. Emma supports this by her comment,

If you didn’t watch the videos, that was like your own fault. You couldn’t say, “Oh, well, she didn’t teach us that.” Well of course she did, you listened to the videos. If you didn’t [watch the videos] – you can’t blame the teacher on that one. Ok, well you didn’t watch the video that is your fault.

Jasmine validates Emma’s comment and notices the autonomous nature of the flipped classroom when she says,

You [the teacher] basically want us to pass, but we are grading ourselves, but you want us to pass, so by doing this flip lesson you want us to learn on our own, where it’s like basically we are passing on our own and not like dependent on like – Oh this teacher ain’t teachin’ us this – so I can’t pass, or we didn’t learn this so I don’t know what it is – so basically it’s like we just – we teachin’ ourselves. I’m like what/why we sittin’ here doing these lessons and I can’t understand. But then I realized like – I’m givin’ myself my own grade. I’m sittin’ here bein’ mad at the
Jasmine’s realization regarding her independence with learning in the flipped classroom was discovered by her during the end of semester interview when she says “I just learned that; I did.” She also said that the independence is one aspect of the flipped classroom that she finds most helpful. Jasmine commented that, “learning on your own, being – like you gotta be responsible enough to watch the videos on your own, get the notes on your own and understand it on your own.” Along with Jasmine, Ava found that independence helpful in the flipped classroom. She stated,

I think the most helpful is that it [the flipped classroom] allows me to try to learn how to do math on my own and it helps me to not have to rely on somebody else, like a peer or a professor. It’s pretty much it. I really like that I’m able to do things on my own.

Similarly, Jason felt that the independence was important but liked the duality of the group work supporting their independent learning through the videos. He stated,

Probably if we didn’t have the groups I would feel dependent, but – or dependent on myself, but with both having, both the groups and the videos, I think it’s the perfect combination of both. Because you can watch the videos on your own but if you also need that help you have your group to go to.

Jason’s response illustrates that he did not feel dependent on the instructor for his learning. He relied on the videos and his group but not the instructor. Jason was learning independently through the videos but depending on his group when needed.
I encouraged independent learning in mid-October while the students were working on the POD’s. I noted,

Students immediately struggled with the POD. I instructed them to go back and review their notes. They could use each other for help but I asked that they refrain from seeking assistance from me. They should work on becoming independent learners. The topic was already taught, so the students should be able to review and relearn material on their own. (October 15, 2014)

I wanted students to become consumers of information and use the notes they take during the videos and in-class to re-teach ideas to themselves.

*Learning through the Video Lectures*

Repeated comments by the adult developmental students demonstrated that they felt that the video lectures were assisting in their ability to learn mathematics. Allison said, “I think this class really really plants everything in my head. It is the only way that I was able to understand it.” The video lectures granted students the time to process information, provided more flexible instruction, gave them a lesson preview, and the video lectures became a study tool, all of which assisted in their mathematical learning and are detailed below.

*Time to process.* The adult developmental students interviewed stated that the flipped classroom gave them the opportunity to think about mathematical ideas before being asked to use them. For instance Emma noted,

I like that there is time [in the flipped classroom], like to sit down, and watch the night before, or sometimes two days before. But it also gave me time to think about how to do it, and when I go to do the homework, or study for whatever I am
doing, I would sit down and be like, “Ok, I understand this.” I can apply it to my homework or my problem. And then we would come into class and be like, “Oh, well I just did that last night.” I knew what I was doing last night when I was watching the video. I could link it and then I could sit down and be like, “Oh, I understand how to do this problem.” And I think it really helped, the time lapse was good for me.

Emma commented how she personally needed the time between initial presentation of new information and the application of that same information in order to learn the objective. Another student, Ava, felt similar to Emma regarding the delay between lesson presentation and mathematical application. She said,

When I am not having to apply it right away, it helps a lot more. When you’re in math class you just learned how to do this and now you have to do it now. Wait! I didn’t even get the chance to let this sink in. That time lapse, it kinda helps me, I process it – it also helps depending on what time I actually do it. I would do my homework after my classes and later on in the evening before I went to sleep I would watch the video. That helped me keep whatever I watched in my head. I am taking that, I’m sleeping on it, and I’m going the next day with a fresh new start. How do I make this apply? It gives my mind a moment to let all the information settle.

Ava found that sleeping on the ideas helped contribute to her understanding. Sara would also watch the videos prior to going to sleep. She stated,
If I watch the video right before I go to bed after you post it, I sleep on it and then the next day I wake up and I’m like – Ok, I understand it; I look over my notes and I understand it.

According to student responses, the flipped classroom helps them as they have time between watching the videos and applying what they have learned in class.

Jason also required time between the videos and class but for a different reason than the students noted above. Jason was more interested in having time to ask questions. He stated:

In high school, I would sit and I would just kind of soak in the lesson and I would go home and try to do the homework that night and I would be like, “I have this question and this question.” Versus I can watch the video, think of questions, then come to class and ask them and have them answered in class.

The video lectures gave Jason the opportunity to process the concepts and ideas and ask questions regarding those concepts and ideas. Sara noted something similar when she said,

I feel like I didn’t have the time to form the questions that I needed to ask [when it was a traditional class] to understand it on my own terms. It really came down to the time I needed to understand it. It just seems like I need a little bit more time sometimes.

The luxury of time between exposure to the video lecture and application during class allowed Sara “to understand it on [her] own terms.” The adult developmental students found that the flipped classroom permits them the time to process incoming information
before being expected to apply it. Based upon their comments, it is evident that this is an
important component to the flipped classroom for these adult developmental learners.

Flexible instruction. The adult developmental students felt that the flipped
classroom enabled more flexible instruction. Since the video lectures were online and
posted in advance, the students were able to engage in the learning experience during
times convenient for them as well as utilize them as many times as needed.

Emma found the videos to be flexible and accessible as she could utilize them
when other learning supports like faculty and fellow students, were unavailable. She
noted,

What if you miss a day [of class] and you need help with the homework, or you
need help with the work that is due? And you don’t have access to a friend that
could help you out, or something like that. I wish my other classes, like my
histories and everything else – I wish they would do [video lectures] – not even a
whole lecture, but just like a little bit. That way if you did need help, you could
do that. Or if you couldn’t go to the study session, it would help you out. I think
because you could – like sit down and pause it [the videos]. It’s not like you’re in
a classroom and you keep going and going – like if I don’t understand what you
said, like two minutes ago, I can go back to that two minutes and watch it over
again.

The video lectures were vitally important to Emma not only for the access to the learning
objectives but also for the ability to continue learning even while missing class. She also
liked the convenience the video lectures provided. She noted,
I think it’s just the convenience that you can access them at any time. Like some professors – yeah, they have office hours. But, what if you can’t go to their office hours? You don’t have the time and you want to sit down and be like, “I want to learn this” but I have to do it at 10:30 at night. You have the luxury and the opportunity to do that.

According to Emma’s statement above, the classroom is mobile and she was able to choose the time and place that worked best for her busy schedule. Jason expressed similar concerns when he noted,

I think it was just having the availability of the videos honestly, and having them on BOLT all the time because, like, I have like a crazy schedule during the rest of the weekends and sometimes with my other professors their office hours don’t line up with my schedule, so if I needed help, I wouldn’t have been able to come to see you, versus the videos. They are on BOLT and I can always – it’s like going to the class multiple times almost.

Both Jason and Emma valued the flexibility and accessibility to the video lectures and the ability of that aspect of the flipped classroom to support their learning.

Allison noted how the videos contributed to the flexible learning environment,

The videos helped so much. They were like – whenever I get confused, I would just rewatch them. Basically [like] having a math class every single day. Like I am able to like keep it fresh in my memory all the time.

Flexible learning created in the flipped classroom was beneficial to Ava as well when she said,
Because even though I was in math class I was learning math on days that I didn’t have classes. I was still applying my math skills every day. I think because I was doing math every day it helped me understand it more. It helped me understand the lesson. So it wasn’t like I am going to do this for a day and then take a break, I didn’t forget information.

The student comment above explains how the flexible environment naturally created in the flipped classroom actually encourages the students to work on mathematics on days the students do not have class, whereby encouraging and supporting their learning. The flipped classroom and the video lectures created a flexible learning environment because students were able to access and watch the lectures when it was best for them. Allison stated how the videos helped to decrease her stress level and work at her pace when she said,

I was always at after school tutoring and she [her teacher] would just be like rushing me through it. And it was so stressful to me, but the videos definitely reassure me and make my stress go down, just because I know it’s always there. It was just a blessing to have those things because, whenever I would get distraught, whenever I would get, like, stressed out, I would just go to them and reassure myself and just keep calm and re-watch them really and I pause them. The fact that you could pause them, write the stuff down, and rewind and re-watch every single little part that like might have confused you.

Allison was able to use the videos to “reassure” herself and make sure she was able to understand the concepts. She also did not need to worry about being rushed through the learning at someone else’s pace. Allison was able to work through the videos at her pace.
through pausing and rewinding whenever she felt it was necessary. Ava also found that learning at her pace was important. She said,

I found myself trying to skip ahead a bit in the videos just because once I understood and got the hang of everything or if I remember a concept from doing it before, I wanted to try to do it myself before you showed us how to do it. And then if I didn’t do it right I wanted to go back and see how you did it. So it’s kinda like I use them to test myself before I actually learned it. So I liked it and everything and no one was there to say you were going too fast. So I can go at my own pace with them.

Again, catering to the adult developmental students’ learning pace was important to them.

Sara notes,

I really – the videos really worked for me because I am able to pause it when I need to. I can do extra problems if I need to. Sometimes when we watch the videos I will go ahead and look at the homework and that helps me too for class. So I know what we are going to be looking at.

It is evident that Sara valued her ability to customize her learning experience through the lesson preview and pace she was able to follow while watching the videos.

Lesson preview. The out of class introduction of the lesson prior to the in-class application appeared to benefit the adult developmental students. The repeated exposure was valued by the students as they liked knowing what they were going to work on ahead of time. The video lectures provided a preview of each lesson for the students that demonstrated what would be worked on the next day in class.
Kristin valued knowing what was going to be taught and reinforced in class each day when she noted, “you go in and you know what you are going to be learning ahead of time. And in class you are pretty much going over it instead of like learning a new thing.” Similarly, Paige was another student who found the videos valuable by presenting a preview of the lesson. She commented, “With the videos, we know what we are going into the day before, and we can – we can look at the videos before our homework if we need help.”

Ava explained how the video lectures gave her an introduction to the lesson that was going to be learned in class. She noted,

The videos were just helpful because like it’s not even just like you didn’t just go over like the lesson that was going to be at hand, you went over things and concepts that you had to learn before to understand how to do the concept that was going to be put to us. So it’s like a refresher on something that we were going to be learning and then we were able to use the concepts and steps that you had learned before and apply them to the lesson that was going to be learned. It’s like refreshing pre-algebra into algebra to understand.

Ava found the video lectures to be a “refresher” for her prior to focusing on the in-class learning activities. Similarly, I noted the importance of the lesson preview in my journal near the end of the semester. I wrote:

The flipped classroom is exposing each of my students to a topic and then allowing for additional practice. There is time for the students to process ideas before practicing a skill. Some students seem like the videos are enough for them and the in-class practice time is simply icing on the cake. I have other students
that the videos and in-class practice complement each other and they need both.

There is a wide range of abilities within the class. Either way, though, I feel like
the majority of students are farther ahead than students in a lecture only class.

(November 17, 2014)

My journal entry alluded to the students’ luxury of processing ideas before coming to
class through the lesson preview provided in the video. Both the adult developmental
students and I were seeing a benefit to those aspects of the flipped classroom.

Similarly, Ava found the videos to be helpful for the lesson preview because there
was just enough information included to give her a foundation on the concept. She noted,

I didn’t think they were too long and I didn’t think they were too short. I think it
was just enough information. You provided at least three examples every time. It
was enough for me to say, “Okay, I understand this; there doesn’t need to be
anymore.” There was a perfect amount of information that I was able to
understand the concept.

Although Ava’s statement focuses on the length of the videos, her statement at the end
describes how those three examples previewed in the video were sufficient to help her to
understand the mathematical ideas in that video.

Paige was the only participant who did not see benefit from the lesson preview
provided by the video lectures. She discussed in her interview that she was not really
watching the video lectures. She stated,

It hindered mine [how the flipped classroom affected her learning]. It’s because
of my fault. It wasn’t the classroom’s fault. It was because I took the videos for
granted sometimes, and I was like I will go right through it, and then I don’t learn
it as well as I would if I watched the videos and came to class. Because when I come to class, we jump into examples, and I – I don’t know where we are. You know what I mean? Like I – I’m like wait, I never even heard of this before, but it was already in the video, but it was my fault.

Paige noted that she was simply fast forwarding through them to copy the notes down but failing to engage in the lesson objective. Her lack of responsibility and accountability was an obstacle to her ability to learn and put her at a disadvantage during class.

*Study tool.* The video lectures were vital to the flipped classroom as they provided all background information on each topic. Students were required to engage with the video lectures on their own prior to attending class. Although students were only required to utilize the videos once, many students revealed that they used the video lectures much more often as a study tool to complete homework, study for quizzes and exams, and help them when they missed class. They commented on the importance of the video lectures as a study tool during the interviews. Emma used the video lectures to help her with completing her homework,

> I would go back to my homework, and if I didn’t understand, “Oh, I don’t understand how to get to that point.” I would go to the video and find where the part of the problem was, stop it, look through it, and play it through again and try to go back to the other problem and finish it.

She went on to say,

> Well I liked it [the videos] because, it was just really helpful to me. I really never had a flipped classroom – so that was really nice and I could do it if I needed help or look over – I’m gonna go look at them for the final. I am gonna rewatch all of
them. If I need help with them, I can look over them. I like the access to them.

Like, it’s mostly today, everyone has access to some computer, even if you don’t have a laptop in your dorm, you can go to the library or the game room and you can watch them. It’s not like a hard thing to do.

Emma explained how accessible the video lectures were and her plans for them in the future as a study tool for the final. Ava also plans to use the video lectures as a study tool for the final,

I use them to study for exams and use them for the final. I would go back over them and I would think about how I felt when I was doing that concept at that time. Most of the concepts that we used before, we kept using throughout entire course. When I would go back and look at the video studying for the final, it would be like – okay, if I watch this video, I know I don’t need to go over this section for the final because I know I am secure about it. Or, I know I don’t have to go over this for the exam and I can spend more time on something else.

Allison explained how she used the video lectures when she said, “I would always, before the exams, I would always go back and rewatch them really quick, even if I fast forwarded a little bit, and just like, take it all in.” Jason also used the video lectures “before a test or after a class or before a quiz – and just be able to watch the lessons again.” He noted, “I will definitely use them for the final.” Paige was another student that said she used the video lectures to study, “I usually [rewatch videos] before a quiz. I would sit in the hallway again and I would watch the video. Like today, I watched – what was it – 761. I watched the video before I went and did the quiz.”
The adult developmental students were seeing such benefit in the video lectures as a study tool that they were recommending them to their roommates that were enrolled in my traditionally taught classes. Even though I was teaching traditionally in my other classes, I still uploaded all video lectures created for the flipped classroom to the traditionally taught classes online course management system. I informed the traditionally taught students that the video lectures were uploaded but did not require students to watch them. Sara made the following comment about her roommate who was struggling,

My roommate, she was having problems, and I know the lectures aren’t required for her class, so I said, “Why don’t you go on and use the lectures that she puts on?” She used them [video lectures as a study tool] to figure it out herself. She used that and Khan Academy to get – helped her form an understanding of what she needed to be doing. I think she had missed class or something.

Kristin was the other student that recommended the video lectures to her roommate when she said, “My roommate is in your Tuesday/Thursday class and she doesn’t have the flipped classroom and she looked at the videos, and I her – she didn’t understand any of the math so I told her ‘Watch the videos’.”

Jason commented how he likes the video lectures more than traditional lectures,

Definitely the lectures or like, your online video lectures [better than traditional classroom] because, in a traditional classroom, you are only given the lecture once. And then you have to go and do the homework versus this where you can have it as many times as you want, and then you can do the homework and then
go to class and ask questions. Where it’s kind of reversed in a traditional classroom.

According to Jason’s comment above, he found success with having the luxury to watch the video lectures as many time as he needed while studying.

*Community of Math Inquiry*

The group work within the flipped classroom created a community of math inquiry. While students were working in their groups they were scaffolding each other’s learning through the analysis and synthesis of ideas. This sharing helped the students to learn by building knowledge and creating an understanding. This section will discuss the collaboration with peers, dialogue and discussion, different perspectives, relaxing climate in the flipped classroom, and challenges of working in groups.

*Collaboration with peers.* Group work was an integral part of each class period as students were required to work collaboratively on the in-class learning activities. The adult developmental students commented on the importance of the collaboration to their learning. Kristin explained that, “It [group work] was actually like – got me more into it – and thinking about it [math] more instead of watching you do it and not asking questions.” In addition to motivating her during class, Kristin also stated “[The group work] made it feel like the class went faster.” Accelerating the pace of the class appears to be important to Kristin.

Kristin enjoyed the ability to work with her peers when she said, “I like working in small groups better because it requires you to not just sit there and listen and be boring. It requires you to interact with people and they can like help you also, teach you different ways.” Paige also commented on her ability to interact with her peers,
We were able to talk to each other. We were able to talk out different problems.
We were able to correct each other. Umm…if we have a question we can answer it out loud – ask it out loud. I think it’s easier to not raise your hand and everyone can talk – you know, together –and they’re like, “Ok, no you’re doing this part wrong.”

Paige especially appreciated the ability to be spontaneous and interact with her peers when she needed to.

Sara explained how her group worked together,

We all work on the problems together and sometimes we split apart, so they would see what I was doing, and we would go step by step, so if I got something wrong, they would see it right away. As where, if I got something wrong and then asked you, I probably would have went the whole way through and then we would have to pinpoint where it went wrong. So it was just helpful to have the small groups because we were all going it step by step together.

Sara found that the ability to work alongside her peers was more helpful when she made mistakes. She did not like working the problem incorrectly all the way through to the end and her groups helped her to avoid that unpleasantness.

Ava was another student that found the group work to be an important component to the flipped classroom. She stated,

I think like it may seem difficult [to work in groups] but I think it’s a good thing to do for students to get involved in because it gives them the chance to be able to work with people in the classroom and also, it puts your skills to work outside the classroom. Math is something you normally do independently and I think once
you figure out to do it by yourself you would be able to do work better in groups with it.

Ava explained how the group work and her ability to collaborate with her peers enhances and builds on everything she is learning to do on her own.

*Dialogue and discussion.* The groups were helpful in facilitating dialogue and discussion between the group members. The mathematical discourse occurring in and between groups encouraged the exchange of ideas. I felt that the students were becoming adept at making explanations. I noted in my researcher journal a month into the semester,

One student publicly admitted she did not watch the video and she felt lost. Another student who had watched it started explaining it to her. Her explanation was excellent and it was readily apparent that she understood the concept of factoring by using substitution. I told her what a great job she did and then asked her to explain it to the class. She used our first example and was so thorough in her explanation that I could not think of anything to add to it other than simply restate what she already said. I could tell there were some students who struggled to understand the second part so I asked her to stop and I caught up with the math work and had her re-explain. Again, she easily, clearly, and simply explained the concept of factoring using substitution. The class appeared to follow along better with the second explanation. (September 29, 2014)

This example illustrates how I attempted to engage the students in class with dialogue and discussion. Another journal entry also highlights group discussion when I noted,
Paige asked why $\sqrt{30} + \sqrt{15}$ could not be added and Taya explained very well why that couldn’t be done and offered an additional example of $x$ and $x^2$ as different and unlike terms and to think of $\sqrt{30} + \sqrt{15}$ in the same way. That worked for Paige and she said, “Ok, I get it.” (November 17, 2014)

Taya used her constructed understanding of adding radicals together to explain it to her peer and even built on her own understanding by relating the new knowledge (adding radical expressions) to previous knowledge (combining like terms). Similarly, Sara realized that the dialogue and discussion she was participating in within her group was beneficial to her understanding when she said,

Not everyone understood it, so I would have to then force myself to explain why I understood it. And that just helped my understanding grow even more. Because then I was not only understanding it for myself but I was trying to make it understandable for other people.

For this particular student, the group work had a dual benefit. Sara was learning when her peers were helping her to understand their constructed understanding and she was learning when she was trying to explain her understanding to her peers. Paige supports Sara’s viewpoint when she says,

It [group work] is beneficial because we can ask each other, “Ok, what did I do wrong here?” You could – some people actually asked, “How do I start this problem?” You [the instructor] are only one person, you can only go around, to certain – to – at different times. We are actually a small group, so we can ask each other, whenever we want. I think it teaches me too. Kind of whenever I am
explaining to them I’m like – say if I’m explaining a problem and I’m like, “Oh, wait, actually, I didn’t actually do this right.”

When Paige would be trying to explain her thought process to her group she would often find mistakes in her work. Paige found that talking through the problems with her group was helpful, “because it puts it in my brain, kind of, puts an explanation to the problem.” I made a similar observation regarding error discovery in my researcher journal during the second flipped class of the semester. I noted,

In one particular group, a female asked a question. Another group member attempted to answer the question and during the explanation an error was communicated. I listened carefully and waited until an appropriate opening occurred in the conversation so that I could jump in. Until that happened, the group members discovered the misinformation and clarified it themselves. It was a wonderful learning experience! It was no longer necessary for me to contribute to the conversation. (September 3, 2014)

From my perspective, it was more valuable for the adult developmental students to discover their errors either in their work or communication than for me to tell them. The students were able to evaluate and interpret their communication and determine its appropriateness in that situation. I was cognizant of the need to create an environment that would encourage conversation and learning between the students. An entry in my researcher journal noted,

I am truly impressed at the dialogue and discussion occurring within the classroom. All of the students are getting along well and working well together regardless of who is in the group. Even the more quiet students are speaking out
and joining in conversation. It is great because it does not seem like anyone is afraid to speak, ask questions, disagree, clarify and explain. (September 29, 2014)

This journal entry provides insight into the environment that existed in the classroom as well as the discussion that was occurring at that point of the semester. A journal entry about a week later noted, “some of the students are getting very good at explaining their work to others.” (October 3, 2014)

Different perspectives. Students noted the importance of the group work for offering different perspectives to the learning objectives. Jason noticed that “for some of the problems there are different ways to solve them.” The group work exposed the students to different ways to think about each of the objectives. Similarly, Jasmine and Sara found the group work beneficial to their learning. Jasmine particularly liked the perspective of her peers when she commented,

I kinda got used to the group work once I seen it from the people in my group point of view and how maybe they are not understanding this and I am so let me explain it, or I’m not understanding it so let them explain it to me. It kinda made more sense, like hearing somebody else explain it. You know how when we do the problems, and you be like, oh can somebody explain why she don’t get it, or like what is missin’. I think its like easier because like people, not saying you are old – but like people from the time in your class understand what’s wrong and what are you missin’ – so it’s good to hear from somebody else in your class around your age.

Sara also noted the importance of the group work when she said,
Small groups was more beneficial for me because if I didn’t understand something, it was – I either asked you, or I didn’t understand it. That was it. And I had the opportunity to ask my classmates and it just helps. I don’t know. It just helps to be able to talk to other classmates. Instead of just getting my own perspective, I am getting everyone else’s perspective and then that helps me because I can think more wide ranged. So I have more ideas to pull from, instead of just my own. So that helped – that actually – that kind of sounds like I’m not independently learning, but I am at the same time because I am learning through everyone else and I am taking that in on my own and pulling from everyone’s ideas to understand it on my own. It just really helped me – seeing their perspective and how they were understanding it, because then I wasn’t just focused on “Ok, this is how I see it and this is the only way I am going to do it.”

Ava liked working with her group as well and respected the varied perspectives when she noted,

I would [like to continue learning math in a flipped classroom] just because it gives me a chance to process; it gives me a chance to kind of reflect on everything, and then it gives me a chance to get other people’s perspectives on math and how they do it. Sometimes people find easier ways to do it. It’s like with more minds, you get more information.

The adult developmental students found the different perspectives valuable to their learning as they could assimilate their thoughts and ideas with those of their peers. The students were using the varied perspectives to construct their own understanding.
Relaxing climate. The daily group work that occurred in-class each day altered the feel of the classroom. Students found the atmosphere in the classroom to be more relaxing and less stressful, like a workshop. Emma found the group work valuable but she was more focused on how the group work changed the classroom environment when she commented,

I think that it made it more comfortable. Like, more – like I could talk to this person. Like if we were just sitting in our rows doing our work by ourselves, it was dead silent. I think it would just be awkward and it would just make everyone feel really self-conscious. If like you are that one kid that goes over and whispers to the other kid, “Hey, can you help me with this one?” and everyone just looks at you. It’s kind of awkward. But, if you are sitting in a group, it’s easier.

Emma valued the relaxing, less structured environment the group work created. Paige too, valued the comfortable atmosphere because she said, “It’s kind of like it’s not a classroom.”

Allison found the flipped classroom to be “more helpful because it’s kind of like a workshop instead of a class.” Jason also liked the relaxed atmosphere that the groups created and the ability to ask questions and quickly and easily check his work with others. He stated:

It’s [group work] very beneficial. In a traditional math class – in all of my other math classes, just you and you are almost hesitant to ask questions. It kind of takes the pressure away almost. It definitely made it more like a, I don’t know – not a team effort but, it seemed a lot more relaxed because we weren’t spending
the whole class lecturing and taking notes. We were all just working. Like most of the time we all will be working in a group and sometimes we will go off and start doing things, but when anyone has a question, we are all able to check our work with one another.

Jason appears to like the workshop feel of the classroom and the luxury of checking in with his peers when it was convenient for him rather than when it was convenient for the class and the instructor.

Sara also felt that the atmosphere in the classroom was more relaxing than others she has experienced. She noted,

I think it’s more relaxing, because people weren’t scribbling as fast as they can to get everything down. So everyone was a bit more relaxed. I am not as stressed out. If this was a traditional class, I would be a mess right now.

Ava’s comment mirrors Sara’s comment above when she said, “It was more relaxing. Like any other time if I would have went to math class, I would be going, ‘Oh my God, I have to go to math.’”

**Challenges of group work.** Working in groups takes time to learn for some students especially at the beginning of a semester when virtually all students are strangers to one another. I noted during the group work exercise in the second week of classes,

When I approached each group I asked them if they had any questions that they could not answer as a group. Several students asked me questions and I redirected the questions back to the group. At first, the students were uncomfortable and wanted me to answer the questions. Gradually the students acclimated to learning on each other for their learning. (September 3, 2014).
I wanted to establish early on in the semester that students should help each other as much as possible wanted to reinforce that during class.

Although the students enjoyed the interaction with their peers, they also found some aspects of it to be challenging for them. Allison expressed her concern,

Just the fact that sometimes they [her group members] weren’t on topic and weren’t like, very focused at times. It was really helpful to have them around, but some of the time when they were talking and doing stuff, I would go off by myself and then, whenever I got confused, I would be like “GUYS!”’, like I would yell at them, like what is this – get back on topic, but other than that it was really good to have them around and like finish our work together.

Sara expressed the same concern with the group work when she said, “I think that is the only problem we really had in our group was we would get side tracked sometimes. That’s the only challenge we really had. We all worked really well together.”

Ava enjoyed the groups and found it helpful to her learning but at the same time she was unsure when another group member did something differently and she did not understand their way of thinking about it. She said,

Sometimes I found it challenging when I didn’t understand how someone got something. I was like wait, how did you get that, and we would have to ask you for clarification – or just the whole fact of like – what if I’m showing them wrong or pushing them in the wrong direction? I would feel bad because they would look back and say, “You made me get something wrong.” It was like the whole intimidation of steering someone in the wrong direction.
It is clear in the statement above that Ava was fearful of collaborating with her peers because she did not want to share something that was potentially incorrect.

Jasmine disclosed in her interview that,

I don’t really like group work because people don’t always follow – people don’t do their part – and I feel as though if I’m in their group I would want everybody in their group to do their part – and not just one person doing their part.

Jasmine communicated concerns about group members not contributing to the common goal and helping each other to learn. She did not say whether her concerns were a problem with her group. Later, Jasmine indicated fears similar to Ava when she noted,

I am antisocial so the smaller group was okay. I don’t really like working with a big crowd. Cause people have different opinions and opinions can clash and everybody start arguing. The only challenging part was when we all didn’t understand so we all was confused and we all needed help. That was the only thing.

Very much like Ava, Jasmine’s challenge occurred when everyone in her group was confused and they needed to reach out to me for additional assistance.

I, too, struggled with the group work but for reasons different from the students. I wrote,

I struggle to understand whether the group work is truly a productive learning task. The learning of the group is controlled by the group, not me. I am not in control and that is a struggle for me. I am not directing the activities and for a self-described control freak such as myself, that is challenging. I feel like if I am not in control, I am unable to decide if learning is taking place. I have to put my
faith in the students and their motivation to learn. Although, this makes the assumption that when I am in control more learning is taking place, which may or may not be the case. I guess I feel more informed when I am directing the learning and thereby assume I can “see” the learning. I have to “trust” that learning is occurring at the rate that is necessary for the course. (September 22, 2014)

Shifting that control and power to the students was a struggle for me throughout the semester. I noted another struggle with the group work in my journal when I wrote,

   Today’s class was especially challenging because the students were easily off task. I felt like it was a constant battle with numerous students. I also had the challenge of trying to manage the different working rates of each group. I have 2 – 3 groups that work much faster than the others and 1 – 2 groups that work much slower than the others. It is also a challenge to try to keep each group/student on task throughout the entire class. Today’s class was discouraging. The students were unmotivated and resistant to all activity.

   I realized today that I have been in denial in most of the previous classes. I have numerous students that work extremely well in groups and together. However, I noticed today just how many students are resistant and do not collaborate well. There are several students (4) in the class that prefer to sit quietly and complete the work on their own. They do not even seem comfortable asking others for their answers so that they can check. (October 17, 2014)

Managing the groups was a challenge for me as the instructor. I struggled with balancing their work rates as well as motivating the unmotivated student.
Way I Teach

My role was an important component to the flipped classroom. Each teacher is unique and has a certain style of teaching. I attempt to create a relaxing environment for the students to learn. In my experience, developmental math students bring much fear and anxiety with them to the classroom and I feel it is my responsibility to do all I can to set them up for success. This section will focus on how I teach highlighting my thorough explanations, instructor presence, and learning aids used in the classroom.

Thorough explanations. Students noted on the beginning of semester survey that they need an instructor that provides thorough explanations when teaching mathematical concepts. Gianna stated that she finds it helpful “when someone can demonstrate and clearly break down a problem in all its parts. Not skip anything because someone else may know it.” Similarly, Alyvia needs good explanations when she said, “A good teacher who can explain mathematics so that not just one kid understands it but the entire class.”

Students spoke very candidly about my thorough explanations in the videos and how that impacted their success throughout the interviews. Emma had the following to say about my teaching and how the videos were thorough, “because how you explain everything. You go through every step. You – the notes are really helpful.” Allison agreed with Emma when she said,

I think it’s the way you teach. Just the way how you describe and explain everything so thoroughly. You did step by step, every single little detail is on the video. I don’t trust the internet the way I trust the videos.
Her statement, “I don’t trust the internet the way I trust the videos” was a humbling experience for me. In her opinion, I was doing a great job in the videos of making it understandable and achievable. So much so, that she did not feel the need to seek out additional resources.

Sara was another student who felt strongly about my teaching. She commented,

I don’t know what it is about the way you teach, but it just really works for me. I – in my experience, it seems like you are very thorough with what we need to be doing and you explain it really really well. I think it really helps that you kind of try to think the way that we’re thinking and try to make sure any doubts you know we are going to be having, you address them before the video is over. So like if I am like, “Whoa, I didn’t get that” you will go over that again. Like I don’t know if you realize that you are doing it, but you are. You are just clarifying it without actually hearing us say, “Oh, I need this clarified.”

Sara’s comment above shows how she benefitted from me anticipating places where the students might misstep in their work and thought process and attempting to fix that before it happens. Ava’s opinion of my teaching corresponds to that of her peers when she says, “I think it was just the whole idea of like how you explain things….You take baby steps into learning a concept. It makes it easier.”

_Instructor presence._ Each instructor has a presence within the classroom that influences the learning environment. In my experience, the majority of students learning mathematics require their instructor to be supportive and provide assistance to be successful. The beginning of the semester survey confirms that adult developmental students feel the same way. Matt noted, “I find to be the most helpful [when learning
mathematics] is when the teacher engages with the class and thoroughly goes through steps to a problem.” In addition to being able to explain the mathematics and engage with the students, students also need to feel comfortable enough to ask questions. Jason noted that he needs,

A teacher who works slowly while presenting notes. Also feeling comfortable to ask questions. I have had math teachers who I felt were unapproachable. The ones who I felt were approachable, I asked them questions and did much better than a class where the teacher is not approachable.

Approachability and engagement are important components of the instructor’s presence for these students.

Other adult developmental students found my presence to be silently supportive as I didn’t “hover” over them but gave them the space to work. Ava stated,

I like that you didn’t hover. In every one of my math classes the teachers always walked around, looked over my shoulder and were always there. “How did you get this? Why did you do that?” And I always felt really intimidated by it. I would always second guess myself. I wasn’t sure, okay am I doing this wrong? So I felt more comfortable because you weren’t there, you just asked if we had any questions, if we didn’t you walked away. Or you just weren’t there and you waited for us to ask you, so I like that. I don’t like when people are over my shoulder when I’m working on math because I’m already intimidated by it. I have you staring at me and I have this in front of me and I just don’t know what to do then.
Emma was not as concerned with “hovering” but rather that I was accessible and available when she noted,

I liked how you would come around and help us when we needed it. You didn’t just stand at the front of the room and not do anything and just did your own thing. You would come around and help everyone, and go back around after you were done, you would go back around again and say, “Do you need help?” again and we would be like no or yes.

Paige agrees with both Ava and Emma when she said, “I like that you come to every – to all the groups one at a time.”

Learning aids. The flipped classroom was complemented with various learning aids that I have developed and used over several semesters. The learning aids are utilized in the classroom to assist and support the students in learning mathematics and are used in all classes I teach each semester. Although these learning aids are activities I use all the time and not exclusive to the flipped classroom, the students referred to them frequently in the data. The learning aids I use are: problems of the day (PODs), brain dumps, course calendar, concept maps, homework, & organization.

PODs are utilized on a daily basis and consist of two mathematical problems. The purpose of the PODs is to get the students immediately on task and to review previous concepts. Since mathematical concepts build on previous ones, it is imperative that students are continually reviewing concepts to remain fresh. Jasmine found the PODs to be the most helpful for her,

The PODs is helpful because we learn before and also current, is there in front of your face. So it’s like you can do it on your own. I like the PODs when we got
the quizzes and you did the PODs that is on the quiz because like if we do it before the quiz, we shouldn’t be able to mess up. Even though sometimes I mess up. It’s because I am writing fast and I be anxious.

PODs on quiz days are always related to the concepts being assessed on quizzes. Jasmine appreciated the PODs because they helped her to review as well as prepare for quizzes.

Brain dumps are used on all exams. Students are given a specific paper prior to the exam and instructed that they may write anything they think they will need to help them to be successful on the exam. Since I want the students to learn for understanding, I attempt to take the pressure off of memorizing with the brain dump papers. Jason noted that the brain dumps were beneficial for him when he said,

I found the brain dumps really helpful because some of my old teachers would make us memorize these outrageously long formulas and I would get them mixed up. And I don’t know, I just – it makes it like – you can worry about the process of doing the equations, than worrying about the formula itself.

Jason’s comment shows how he was able to use the brain dumps to relieve the pressure of memorizing mathematical formulas. Instead, he was able to focus on completing the work.

All students are given a course calendar on the first day of the semester. The course calendar includes all homework assignments, due dates, quizzes, and exams. The calendar was created to assist the students with time management and planning. Emma appreciated the organization of the course,

It’s more organized than any of the other math course I have had. The other ones we didn’t get calendars – we didn’t get – organized things – we always knew
what was gonna happen. When we would have a quiz, sometimes we wouldn’t know about a quiz till the day before [in her other classes]. So I liked knowing when everything was.

The course calendar Emma received on the first day of class helped her stay organized and prepare accordingly for each day of class. Ava felt the course calendar helped the workload feel manageable when she said,

It [the workload] was manageable. You had a calendar for us, and you told us what was due, what day, when we had a test, when we had a quiz, it wasn’t hard to manage the responsibility. It was just if you stayed organized and if you were on top of everything and you paid attention.

Ava found the organization important and helpful for her to manage the workload.

Concept maps are used as a teaching tool and contain all important information regarding a topic. The concepts maps are organized to illustrate relationships between ideas and include all relevant information regarding the topic. Concept maps are handed out in advance of the topic and associated video lecture. Snapshots of the concept maps were included in the videos. Paige found the concept maps helpful,

I liked having the concept maps – how umm, how you do it by the sections and the one chapter. So you have – whenever you can go put it on your brain dump, you understand everything in the sections. Like you can study it that way too. You know what I mean? You have an example and an explanation of how to do it, and you can just go right back and look at that if you are doing your homework or something.
Paige used the concept maps to help her complete her homework and would use information from the concept maps on her brain dump paper for her exam.

Homework was assigned every day and purposefully selected to support the video lecture and in-class learning activities. Odd problems were always assigned and students were expected to check their answers in the back of the book. Students were required to mark their answers correct or incorrect prior to turning it in. Homework was graded on completeness, not correctness. Kristin felt that, “the homework was helpful every night because it kept you on track of what you were learning.” Emma also found the homework to be a helpful tool that supported her learning when she said,

The practice [the homework] and also that we could look to see if we got it right in the back – in high school and in other math courses, we only do the evens, and if you got it wrong, you didn’t even know you got it wrong until – if we checked it or if we didn’t check it. You didn’t really know.

Emma valued the ability to check her own work to determine whether she was getting the problems correct or incorrect with the answers in the back of the book.

Sara was another student that commented on the organization of the class and how it assisted in her learning and success,

Well, the organizational factors have definitely helped me. The brain dumps have helped me. There is so many things that have helped me. The homework every night, the ten points for the videos, has really helped my grade. Just things like that have really helped. And then, the things that have been a challenge, the homework, doing it every night. That has been a challenge. But it’s a helpful challenge.
It is apparent that Sara utilized several of the learning aids during the semester. Ava mentioned some of the learning aids when she said,

You give us all the tools to succeed. You make sure we have our calendar, all of our notes and everything in order and make sure we’re organized….You made us look over things; you made us stay organized. That was always my problem. I didn’t realize how important it was to be organized in math; I was like okay I am taking notes that should be good enough – but if I kept everything in order like notes, quizzes, exams, and homework and if I would’ve kept all of that stuff in one area and had it to look back as a reference I would’ve been able to study better.

Ava noted how she was given “all the tools to succeed” in the course and how the structures and organization was beneficial for her.

Summary

Initial data showed that adult developmental students entering this course have struggled to learn mathematics in the past. This lengthy struggle created excessive frustration for the students. Data collected over the course of the semester showed that the flipped classroom changed the student’s initial perceptions about mathematics. As their perceptions were changing, the students confidence in learning mathematics increased and they found learning mathematics in the flipped classroom to be more enjoyable than past experiences. The study also found that students developed relationships with their classmates and the instructor and gained a new found independence with learning mathematics. Additionally, the flipped classroom gave the student’s time to process the mathematical ideas before being asked to apply them,
created a flexible learning environment, and provided a preview of new information.
Finally, students found the flipped classroom to be a supportive learning environment
that encouraged collaboration with their peers and provided valuable assistance from the
instructor.

Quantitative Findings

The following sections illustrate the quantitative findings. These findings are a
result of the weeks 4 and 10 surveys completed by the students, minute papers, and the
end of semester faculty evaluations. The demographic data obtained from the beginning
of semester survey is detailed and discussed in chapter three.

Weeks 4 & 10 Surveys

The survey that was administered during weeks four and ten (Appendix E)
focused on the videos and the in-class learning activities. The week four survey (Table 1)
was positive and encouraging in almost all areas. The areas that were the most negative
were concerned with sound quality of the video lectures, accessibility of videos, and
enjoyment of in-class learning activities.

Week four survey data revealed that students felt that the video lectures were
informative and contained quality examples. The students also felt they were well
explained. The week four survey also shows that students felt that the in-class learning
activities were helping them to learn from their peers and providing opportunities for
more feedback from their peers and myself. I felt that I was able to provide more
feedback to the students in the flipped classroom and noted in my journal,
I was able to get to each group twice and interact with them. I was able to look at
their work and provide feedback. Some students completed the first problem with
a leading coefficient of -1 in the equation and did not notice that that is a problem for the AC method. I was able to have an engaging discussion with them that I don’t think would have been as productive would it have been whole class discussion while I was lecturing. (October 3, 2014)

Table 1

*Week 4 Survey*

<table>
<thead>
<tr>
<th>Question</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) The video lessons have good sound quality.</td>
<td>5%</td>
<td>9%</td>
<td>23%</td>
<td>36%</td>
<td>27%</td>
</tr>
<tr>
<td>2.) The video lessons have good problem illustration.</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>36%</td>
<td>59%</td>
</tr>
<tr>
<td>3.) The video lessons are well explained.</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>27%</td>
<td>68%</td>
</tr>
<tr>
<td>4.) The video lessons are easy to access and watch.</td>
<td>0%</td>
<td>5%</td>
<td>27%</td>
<td>23%</td>
<td>45%</td>
</tr>
<tr>
<td>5.) The in-class learning activities are helping me to learn from my peers.</td>
<td>0%</td>
<td>9%</td>
<td>9%</td>
<td>41%</td>
<td>41%</td>
</tr>
<tr>
<td>6.) The in-class learning activities reinforce the topic.</td>
<td>0%</td>
<td>5%</td>
<td>9%</td>
<td>32%</td>
<td>55%</td>
</tr>
<tr>
<td>7.) I enjoy participating in the in-class learning activities.</td>
<td>0%</td>
<td>0%</td>
<td>27%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>8.) The in-class learning activities provide the opportunity for more feedback from my peers and the instructor.</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>36%</td>
<td>59%</td>
</tr>
</tbody>
</table>

A couple of days later I made a similar entry when I said,

On days like today, I thoroughly enjoy working with the groups. Since the topic was an easier topic to understand, I was able to circulate among each of the groups and interact with them. I am enjoying the interaction. I have the opportunity to provide one-on-one and small group instruction that I have not
previously been able to do so. I also love the fact that the students are helping each other so much. During classes like today, students are doing all of the talking and explaining. (October 8, 2014)

The out of class video lectures freed up class time for more active learning and enabled me to interact with each of the groups and provide valuable feedback.

Based upon the week four survey and comments students made during class, I needed to improve the sound quality of the videos. I definitely struggled in this area. I commented on my sound issues in my journal when I wrote,

I have been having issues with the sound in the video lectures. I am using a microphone but am struggling to determine where it should sit in relation to my mouth. I am also playing around with the sound settings on the computer. Based upon student feedback and trial and error, I have found that the microphone needs to be about one inch from my mouth and the sound on my computer needs to be set at 50. The sound issue has been a constant struggle. I will most likely have to re-record some of the early video lectures for use next semester. (October 6, 2014)

It took a while, but I was able to finally resolve the sound issues with the video lectures.

I attempted to mitigate student concerns with the in-class learning activities as well. During the planning phase of this action research study, I gathered and developed various activities to be utilized during class to complement the video lectures and extend the students’ learning (Appendix D). Throughout the first half of the semester I utilized the following activities during class: predict quiz questions, roundtable exercise, error analysis, study plan, choose five strategy, practice quiz, and jigsaw review activity.
The first activity I implemented was the roundtable exercise. I noted in my journal regarding this activity,

I wrote 4 problems on the board: 2 exponential problems and 2 scientific notation problems. I asked each student to use a scrap piece of paper and write down one problem from the board. Each student was required to choose a different problem [from their group member]. They were instructed to complete step one and only step one and then pass their paper to the right. After passing their paper they were required to analyze the first step completed by one of their group members and then add step two. The process was to be repeated until all problems were complete.

The adult developmental students really struggled with this activity and found it to be very challenging. Their work ethic was wonderful and although it was difficult for them, they persisted through the difficulty. I was truly amazed and impressed at their perseverance. I circulated throughout the groups providing assistance when necessary and clarifying any mistakes that were overlooked. I encouraged critical thinking and discussion and would not answer their questions directly but would rather pose another thought provoking question to elicit a response that would answer their original question.

The roundtable activity took the remainder of the class time. I asked students to put the work for each problem on the board. I led the class through analyzing each step of the work shown to determine if it was right or wrong. Several mistakes were found, discussed, and corrected. I encouraged all students to copy down all four problems.
Although I felt like class time was used very effectively and students were engaged in active learning there was a lot of struggle that I am not sure was positive struggle and I found the activity personally exhausting as the instructor. I am not sure if I will use this activity again. (September 8, 2014)

The roundtable exercise used a large portion of class and was difficult for both myself and the students. The students appeared to struggle with this activity because they had to determine how the problem was started and then add the next step based upon the method used by a different student to begin. The struggle seemed to grow from the fact that the first step may not have been started in a way that they understood. This suggested that the students were uncomfortable proceeding with work that did not correspond with their preferences and/or understanding.

I struggled with the activity because I felt like I had to continually encourage the students to persist through their difficulties. It was demanding coaching the students through those couple of problems. This activity was so time consuming that we were unable to complete any other activities during class. A part of me also struggled with the fact that I had to surrender additional classroom control and transfer the responsibility of productive work onto the students. I felt as though I was engaged in a delicate balancing act trying to plan and utilize productive in-class learning activities but always cognizant of the need to allow ample practice time for students to develop a comfort level with the objective.

During the last few minutes of that same class I attempted to use another learning strategy, predict quiz questions. I noted, “I was asking students to predict their quiz questions. However, this request took place in the last minute of class so I do not
anticipate that the majority of the students will engage in this task.” (September 8, 2014)

Reflecting on this now, trying to implement another in-class learning activity with only minutes remaining seems poorly planned and rushed.

Another in-class learning activity that I used was error analysis. With error analysis, I asked students to look at their own work or the work of a peer and try to determine the mistakes. I wrote in my journal,

When students began finishing the two PODs I asked each group to examine their quizzes that were returned today on exponents and identify their mistakes and work to correct their errors. I felt that some students were simply interested in copying the correct work from a group member that got that problem correct. (September 15, 2014)

I was concerned that students were copying work rather than trying to figure out where the misunderstanding occurred. I used that same activity a second time and I noted,

Since the class just had an exam and I returned them today, I asked them in their groups to look at the section on scientific notation on their exams. I used their exams as error analysis and asked them in their groups to determine what their mistakes were so they do not make those same mistakes on today’s quiz. Some group members seemed to monopolize the group discussion time because they wanted to figure out all of their mistakes. This is a good thing but that means that other students do not have the opportunity to receive feedback from their peers. Some students were also very needy with me as well because I was unable to touch base with every group during this activity. I also saw a few students simply copying down someone else’s correct work. (September 22, 2014)
Again, some students were not using the resources I was implementing effectively as learning tools.

Throughout the semester I struggled with the in-class learning activities due to the time required to complete each one. I noted in my journal,

Each activity takes much longer than I anticipate but the collaboration seems to be of good quality so I hate to cut it short. I feel though, that I need to start setting a schedule and time limit on class activities and stick to it. (September 15, 2014)

Over the first half of the semester I used almost all of the in-class learning activities included in Appendix D. About a month later I expressed frustration with the in-class learning activities when I wrote,

I am also finding that 50 minutes just doesn’t seem like enough time to accomplish everything that I feel/want to accomplish. We no sooner get into an activity and we need to move on. We usually only have time for 1 – 3 problems during group work because there are other things that I must do like administer quizzes and such. (October 17, 2014).

A couple of days after that journal entry I asked students to give me some informal feedback because both the students and I were becoming frustrated and discouraged. I wrote in my journal,

One student actually said, “I can’t learn like this!” when I requested they move with their groups. I was disheartened because I was forcing something on a student that was obviously not working for them. I realized today that I will never win a battle between me and the students when they refuse to work. Change has to occur and I am not sure what to do. (October 17, 2014)
I used a minute paper to solicit their opinions and wrote in my journal,

In an effort to problem solve, I decided to do a minute paper. I explained to the students that I was discouraged, not with them personally, but with the fact that what I had intended [new groups and in-class activities] was not working for them. We did the minute paper immediately at the beginning of class. I asked students to put “changes needed” on one side of the paper and “what is working” on the other side. I was careful to give them ample time to complete both sides.

I was able to immediately see several themes from both sides of the papers. As for the changes that the students need to make it a more conducive environment for their learning, they said:

• prefer quizzes at the beginning of class rather than at the end
• more difficult examples during class/videos
• choose their own groups
• go over questions from previous night’s video

As for what is working, the students noted:

• the videos
• PODs
• the groups

There were three minute papers that really caught my attention: “The workload is a lot but it keeps my math juices flowing.”; “Everything [is working]! This is the most I’ve ever understood. I don’t want it to change. Your teaching really works for me. I understand that other people learn differently and I respect
that but changing it worries me.”; “I wish this class was 2 hours. 50 minutes is not enough to get through everything.”

I explained that I was willing to make the changes that they suggested. I asked them to understand though with doing the quiz at the beginning of class I could not allow them any extra time to complete it because we still have a lesson to learn. When doing the quiz at the end of class I can always offer them an extra five minutes before the next class needs to come in. Also, for the questions from the videos I explained that that would require more responsibility from them. I would certainly be happy to address any questions, but they need to have questions and ask them. They were comfortable with all of that [the changes they requested] for now. They did however, wonder if these changes would be permanent. I explained that if they communicate with me, that I am more than willing to make additional change. I was impressed with how calm I was at making the changes they suggested. I was a little worried when I asked the students about the changes needed because I wasn’t sure if I could meet their expectations. Their suggestions will require a little more work from be but they are completely doable, so I am comfortable working for that change. (October 22, 2014)

The changes were implemented during the next class and consisted of:

- allowing the students to choose their own groups
- administering the quizzes at the beginning of the class rather than at the end (but may change back depending on student preference)
- using more difficult examples in the videos and during class
• going over student questions from the previous night’s video(s)

• adjusting sound quality for improvement

Additional student feedback was collected a few days later using the week ten survey (Table 2).

According to the survey data there were several improvements over the course of the semester based upon the number of students that agreed or strongly agreed with the survey statements. Students felt that: the sound quality improved over the course of the semester, the video lessons were easy to access and watch, the video lessons were well explained, and that in-class learning activities reinforced the topic presented in the video lessons.

Survey data also reveals a few areas where student opinions were not as favorable from week four to week ten based upon the percentage of agree and strongly agree responses. Student opinion declined in the following categories: good problem illustration (95% to 91%), the in-class learning activities are helping me to learn from my peers (82% to 67%), students enjoy participating in the in-class learning activities (72% to 67%) and the in-class learning activities provide the opportunity for more feedback from my peers and the instructor (95% to 81%).

When the adult developmental students were asked what changes they would suggest for the video lessons, numerous students requested more difficult examples to be included in the video lessons. When asked for changes to the in-class learning activities students either had no response or had no suggestions. This seems puzzling when the survey data revealed that they were not enjoying the in-class activities or benefitting from them as much as other aspects of the flipped classroom.
### Table 2

**Week 10 Survey**

<table>
<thead>
<tr>
<th></th>
<th>Week 10</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) The video lessons have good sound quality.</td>
<td>0%</td>
<td>0%</td>
<td>24%</td>
<td>24%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>2.) The video lessons have good problem illustration.</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>48%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>3.) The video lessons are well explained.</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>43%</td>
<td>57%</td>
<td></td>
</tr>
<tr>
<td>4.) The video lessons are easy to access and watch.</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>24%</td>
<td>67%</td>
<td></td>
</tr>
<tr>
<td>5.) The in-class learning activities are helping me to learn from my peers.</td>
<td>5%</td>
<td>0%</td>
<td>29%</td>
<td>29%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>6.) The in-class learning activities reinforce the topic.</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>43%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>7.) I enjoy participating in the in-class learning activities.</td>
<td>0%</td>
<td>10%</td>
<td>24%</td>
<td>43%</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>8.) The in-class learning activities provide the opportunity for more feedback from my peers and the instructor.</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
<td>43%</td>
<td>38%</td>
<td></td>
</tr>
</tbody>
</table>

### Faculty Evaluations

Faculty evaluations (Appendix G) consist of 17 questions designed to evaluate the faculty member and the course. Faculty evaluations were administered within the last two weeks of the semester and completed by students enrolled in the course. Faculty evaluations are represented in two tables. Table 3 illustrates the results of my faculty evaluations completed by students in the flipped class section. During the same semester I was completing this action research study I also taught two sections of the same class, Intermediate Algebra, using traditional lecture methods. Faculty evaluation data obtained from both traditionally taught sections is shown in Table 4. The traditionally taught
classes followed the same curriculum, pace, and used the same course materials but were taught through in-class lecture methods and did not include in-class learning activities and group work. The video lectures created for the flipped class were uploaded as a resource to the online course management software for the traditional classes but students were not required to engage in them for class.

According to the first faculty evaluation survey question, 22.3% of students noted that their initial interest in the course was low to very low for the flipped class section compared to 16.7% in the two traditional class sections. Scores were relatively close for the next nine questions which focused on the instructor. The flipped class ranked my teaching at 100% for almost always or usually, in all categories except one, explained the evaluation of students’ performance, where they ranked me at a 95%. In the traditionally taught classes, I earned a 100% in two categories and nineties in all other categories with the lowest percentage being 93% for almost always or usually conveying the significance of the subject matter.

When students were asked to rank the course, there were larger differences in the rankings between the flipped class and the traditionally taught classes. Table 5 illustrates the scores for the five course related questions (numbers 10-14) and represents the responses that ranked very high in those questions. Table 5 also includes the final two evaluation questions which rated the course and course materials (numbers 16 and 17) and represents the responses that were excellent.
Table 3

**Flipped Class Faculty Evaluations**

<table>
<thead>
<tr>
<th>Specify your original motivation or desire to take this course.</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very Low</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My initial interest in the content of this course was. . .</td>
<td>44.4%</td>
<td>11.1%</td>
<td>22.2%</td>
<td>5.6%</td>
<td>16.7%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Specify the frequency with which your instructor used the following teaching procedures.

<table>
<thead>
<tr>
<th>Specify the frequency with which your instructor used the following teaching procedures.</th>
<th>Almost Always</th>
<th>Usually</th>
<th>Sometimes</th>
<th>Almost Never</th>
<th>Never</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Showed enthusiasm for teaching.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3. Was prepared for class.</td>
<td>94.4%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>4. Used grading procedures as specified in the course outline.</td>
<td>94.4%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5. Explained the evaluation of students’ performance.</td>
<td>88.9%</td>
<td>5.6%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>6. Made explanations that were clear and to the point.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>7. Conveyed the significance of the subject matter.</td>
<td>88.9%</td>
<td>11.1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>8. Facilitated independent thinking and problem solving.</td>
<td>94.4%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>9. Encouraged students to be involved in the learning process.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

How has this course helped you to progress in the following areas?

<table>
<thead>
<tr>
<th>How has this course helped you to progress in the following areas?</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very Low</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Comprehension of terminology and other factual knowledge.</td>
<td>88.9%</td>
<td>5.6%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>11. Knowledge of fundamental theories and principles.</td>
<td>83.3%</td>
<td>16.7%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>12. Ability to apply course material to improve problem solving skills.</td>
<td>88.9%</td>
<td>11.1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>13. Understanding how to gain new knowledge in the field.</td>
<td>83.3%</td>
<td>16.7%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>14. Enhancement of communication skills.</td>
<td>88.9%</td>
<td>11.1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Rate the course and instructor.

<table>
<thead>
<tr>
<th>Rate the course and instructor.</th>
<th>Excellent</th>
<th>Above Average</th>
<th>Average</th>
<th>Below Average</th>
<th>Poor</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. I rate this instructor as. . .</td>
<td>94.4%</td>
<td>0%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>16. I rate this course as. . .</td>
<td>94.4%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>17. I rate the course materials as. . .</td>
<td>88.9%</td>
<td>11.1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 4

*Traditional Classes Faculty Evaluations*

<table>
<thead>
<tr>
<th>Specify your original motivation or desire to take this course.</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very Low</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My initial interest in the content of this course was...</td>
<td>35.7%</td>
<td>28.6%</td>
<td>19%</td>
<td>14.3%</td>
<td>2.4%</td>
<td>0%</td>
</tr>
<tr>
<td>Specify the frequency with which your instructor used the following teaching procedures.</td>
<td>Almost Always</td>
<td>Usually</td>
<td>Sometimes</td>
<td>Almost Never</td>
<td>Never</td>
<td>No Response</td>
</tr>
<tr>
<td>2. Showed enthusiasm for teaching.</td>
<td>97.6%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3. Was prepared for class.</td>
<td>95.2%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>4. Used grading procedures as specified in the course outline.</td>
<td>95.2%</td>
<td>2.4%</td>
<td>0%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5. Explained the evaluation of students’ performance.</td>
<td>81%</td>
<td>14.3%</td>
<td>2.4%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>6. Made explanations that were clear and to the point.</td>
<td>90.5%</td>
<td>7.1%</td>
<td>0%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>7. Conveyed the significance of the subject matter.</td>
<td>78.6%</td>
<td>14.3%</td>
<td>2.4%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>8. Facilitated independent thinking and problem solving.</td>
<td>85.7%</td>
<td>11.9%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>9. Encouraged students to be involved in the learning process.</td>
<td>92.9%</td>
<td>7.1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>How has this course helped you to progress in the following areas?</td>
<td>Very High</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Very Low</td>
<td>No Response</td>
</tr>
<tr>
<td>10. Comprehension of terminology and other factual knowledge.</td>
<td>57.1%</td>
<td>23.8%</td>
<td>11.9%</td>
<td>2.4%</td>
<td>0%</td>
<td>4.8%</td>
</tr>
<tr>
<td>11. Knowledge of fundamental theories and principles.</td>
<td>61.9%</td>
<td>23.8%</td>
<td>11.9%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>12. Ability to apply course material to improve problem solving skills.</td>
<td>66.7%</td>
<td>16.7%</td>
<td>11.9%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>13. Understanding how to gain new knowledge in the field.</td>
<td>57.1%</td>
<td>28.6%</td>
<td>11.9%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>14. Enhancement of communication skills.</td>
<td>59.5%</td>
<td>26.2%</td>
<td>11.9%</td>
<td>2.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Rate the course and instructor.</td>
<td>Excellent</td>
<td>Above Average</td>
<td>Average</td>
<td>Below Average</td>
<td>Poor</td>
<td>No Response</td>
</tr>
<tr>
<td>15. I rate this instructor as. . .</td>
<td>78.6%</td>
<td>16.7%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>16. I rate this course as. . .</td>
<td>47.6%</td>
<td>31%</td>
<td>16.7%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>17. I rate the course materials as. . .</td>
<td>50%</td>
<td>23.8%</td>
<td>21.4%</td>
<td>4.8%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 5 illustrates large differences in student opinion regarding the flipped course and traditionally taught classes. It appears from the percentages below that students found the flipped class to be more helpful in extending their mathematical knowledge and more beneficial overall as compared to the traditionally taught classes. Overall, 95% of the students in both the flipped class and the traditionally taught classes rated me as an excellent to above average instructor.

Table 5

*Comparison Table of Flipped Class and Traditional Classes Faculty Evaluations*

<table>
<thead>
<tr>
<th>Question</th>
<th>Flipped class</th>
<th>Traditional classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension of terminology and other factual knowledge (methods, trends, . . .)</td>
<td>88.9%</td>
<td>57.1%</td>
</tr>
<tr>
<td>Knowledge of fundamental theories and principles.</td>
<td>83.3%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Ability to apply course material to improve problem solving skills.</td>
<td>88.9%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Understanding how to gain new knowledge in the field.</td>
<td>83.3%</td>
<td>57.1%</td>
</tr>
<tr>
<td>Enhancement of communication skills, (orally, in writing, or performance).</td>
<td>88.9%</td>
<td>59.5%</td>
</tr>
<tr>
<td>I rate this course as . . .</td>
<td>94.4%</td>
<td>47.6%</td>
</tr>
<tr>
<td>I rate the course materials as . . .</td>
<td>88.9%</td>
<td>50%</td>
</tr>
</tbody>
</table>

In addition to the survey question portion of the faculty evaluations, students may also choose to leave free response feedback of their choosing on a half sheet of paper to be included in the faculty evaluations. Sixteen students chose to leave additional feedback from the flipped class. Of those 16 responses, four students noted that I was “the best math teacher” they ever had. One student commented, “At first I wasn’t excited about this but she was the best math teacher I ever had. I learned so much this semester and understand math.” Another six students noted that I was a “great teacher.” A different student said, “She always has great enthusiasm to teach students. She makes
learning math desirable and allows students to learn in their own way. A great woman and professor.” Students also noted how the class was informative, great, and enjoyable when one student noted, “Enjoyed the class! Helped me learn/re-learn algebra. The video lessons were great – like how we had time to go over the problems in class from the video.” Another student wrote, “She works with her students. At first I didn’t realize what she was doing until now. She creates an environment for student to pass not to fail. She was a great teacher and I learned a lot.” Each one of the 16 responses was positive comments either about the class or my teaching.

Summary

The quantitative findings showed that students found the videos to be accessible and well explained. However, student opinion declined when asked if the in-class learning activities were helping them to learn from their peers and regarding their enjoyment of those in-class learning activities. When given the opportunity to offer suggestions for improvements, the majority of students had no suggestions. Faculty evaluations of my teaching and the course were overwhelmingly positive in all categories but the percentages were higher in the flipped classes.
CHAPTER 5
DISCUSSION AND IMPLICATIONS FOR PRACTICE

The focus of this action research study was to explore a constructivist, flipped classroom with respect to developmental mathematics students. The findings generated from the study were presented in chapter four. This action research study was guided by the following research questions: (a) how can a flipped classroom be successfully implemented within a developmental classroom? (b) how does a flipped classroom, from the perceptions of adult learners, promote a community of math inquiry in a developmental mathematics classroom? (c) what are the perceptions of adult learners concerning the flipped classroom and the impact on learning for developmental mathematics from the perspective of participating adult learners? (d) what practical strategies were most effective at facilitating a flipped classroom from the students and faculty member’s perspective? and (e) what is the degree of satisfaction of the flipped classroom from the student’s perspective?

The findings presented in the previous chapter were presented in two sections: qualitative findings and quantitative findings. The qualitative findings presented seven themes developed from the data: beliefs about math, ongoing transformations, shared connections, enhanced independence, learning in the flipped classroom, community of math inquiry, and the way I teach. The quantitative findings focused on the weeks four and ten surveys as well as the faculty evaluations completed by students at the end of the semester.

This final chapter is organized into four sections. The first section will discuss the relevant findings related to the theoretical frameworks of constructivism and
community of math inquiry. The second section discusses implications for practice in developmental mathematics and adult education. The third section discusses the limitations presented in chapter one and provides suggestions for future research. The chapter concludes with a personal reflection by the researcher.

Relevant Findings

The data collected from the beginning of semester survey, weeks four and ten survey, end of semester interview, researcher journal, minute papers, and faculty evaluations provided an abundance of findings related to constructivism, community of math inquiry, and my role in the classroom. These findings will be discussed in the following sections.

Constructivism

Constructivism assumes that learning takes place within the individual through their personal construction (Liu & Matthews, 2005). Students construct their knowledge and understanding by processing the ideas and working to make sense of them (Gordon, 2009). They make associations, classifications and organize the ideas with their previous knowledge (Fosnot, 1996). Social interactions within the in-class groups further encourage the construction of knowledge through the various perspectives of the social group (Powell & Kalina, 2009). Learning occurs when different perspectives are synthesized, analyzed, and integrated with the learner’s previous ideas and understanding. Collaborative learning as well as instructor feedback supports the scaffolding of learning.

Scaffolding is a level of support provided by the instructor and fellow students to assist the learner in achieving more understanding than they would on their own. This
support is achieved through collaborative learning with the various perspectives and explanations as well as how the lesson is broken down, presented, and explained by the instructor. Students need support to create knowledge and that is done through scaffolding their learning (Powell & Kalina, 2009).

Within this particular study, the video lectures seem to scaffold the students learning, indicative of an important component to constructivism. Students were able to pause, rewind, and fast forward the video lectures. These features allowed the students to attempt some of the work on their own and then return to the video to check their work and understanding as well as progress at a pace that was comfortable for them. For example, Allison explained that,

I always wanted to try it by myself first. Cause it’s rewarding to see if you got through the answer right and if I did it the exact same way that you did. It’s just a good feeling to know that I am doing everything the way I should be.

Introducing the learning in this manner created a nonthreatening environment, scaffolded through the video which appears to be a benefit of the flipped classroom. Students have the opportunity of learning at their pace and on a schedule that works for them. Also, since the instructor is on the video and not in person, students can make mistakes without fear of embarrassment or intimidation. This type of learning environment supports the students in building their confidence at the same time they are building their understanding. Although they are attempting the mathematics on their own, the instructor is with them all the time scaffolding their learning through the video lectures. Each one of these aspects of the video lessons is also effective at facilitating a flipped classroom.
The sections that follow integrate constructivism within the findings of the study. The discussion is framed around learning independence, empowerment, collaborative work in the classroom, and limitations of constructivism.

**Learning Independence**

The constructivist nature of the video lecture portion of the flipped classroom also helped students become independent learners which was an important outcome for the students. They expressed how they found it beneficial to learn on their own and how that empowered them because the students discovered that they could learn mathematics. Ava’s comment supports this when she said it “allows me to try to learn how to do math on my own and it helps me to not have to rely on somebody else, like a peer or a professor. I really like that I’m able to do things on my own.” Independence and empowerment was developed from the students realizing that they were trying the mathematics themselves first and learning how to do it without additional assistance while engaging in the video lectures. The ability to become independent learners appeared to have a significant impact on their learning.

The capacity for students to learn autonomously is a new insight regarding the flipped classroom. The previous literature on flipped classrooms examines perceptions of both faculty and students, academic involvement of students in a flipped classroom, whether students are receptive to the flipped classroom, and comparison of academic performance of students in flipped classrooms against students in traditional classes. The previous literature that was examined does not discuss the students’ transitioning to independent learners as the result of the flipped classroom. Independent learning is also significant for the field of developmental mathematics. Wambach & Brothen (2000) note
that developmental learners are dependent on their instructors and there is a need to help them become more independent. What aspect of the flipped classroom develops the independence? Based on student comments it appears that the independence begins with the video lectures. As noted above, Ava noted how they allowed her “to try to learn how to do math on my own.” Sara also commented on the significance of learning on her own, “I loved the feeling that I’m learning on my own and I am doing really really well. It’s not all based on just you [the instructor]. Like I’m teaching myself and that just makes me feel so good.” It is evident that students are craving independence in their learning. This action research study demonstrates that developmental learners want to escape their dependence on their instructors and the flipped classroom is helping them to do that.

*Empowerment*

The students noted in the beginning of semester survey how they struggled for years to learn mathematics and how frustrating the journey had been for them. For example, Sara stated, “I sat in traditional classrooms for 12 years not understanding what I was doing.” Paige said, “I am horrible at math! I have no successes.” John noted, “I have a rough history with math. I always had trouble understanding it, especially in high school.” Students expressed their defeat from their experience of learning mathematics and how they struggled with it for many years. This is consistent with Hyslop-Margison & Strobel (2008) who posit that students’ belief about mathematics and their ability to learn it inhibit their learning.

Many of the students entered the course defeated, so much so that they did not even expect that learning was possible for them. However, once this fallacy was proven
inconsistent with their prior beliefs, the students begin to show up to class differently.
Sara noted that her perception about learning math was different. She stated,

I know it’s possible now, like before I thought I was always going to suck at math. I always thought that I was never going to get better at it and I was always going to hate it, and that I would never be able to learn it on my own – like I did with other classes.

Sara became empowered when she learned that she can learn. From there, she embraced the fact that she could learn a subject that had defeated her for years and now she gets immense pleasure and satisfaction from teaching her peers the subject that in some ways held her captive. This new found ability motivated her to delve into a subject knowing she may be confused for a moment but realizing her confusion was not final nor an indication of her failure in the entire subject of math. Sara realized that she could now overcome her struggles with mathematics. This was also the case with several other students.

Hyslop-Margison & Strobel (2008) assert that part of mathematical knowledge construction is creating a new mindset regarding mathematics. The students in this study seemed to create new mindsets regarding their ability to learn mathematics. As a result, they do not want to return to a traditional classroom but want to continue learning in the flipped classroom. Allison’s comment supports this when she says,

I like it [learning in the flipped classroom] a lot. It’s so much better. And like I said, it’s just, the whole learning experience. The people in our class, the people that I sit around, they all feel the same exact way. We all feel like – we were all
talking about—we almost failed algebra in high school and it’s completely different now. Just the whole experience itself is so much better.

The flipped classroom appears to have helped the students find their ability to learn mathematics because they feel they get time to process ideas, reflect on their learning, and seek other perspectives. This reinforces what Vasquez Mireles, Offer, Ward, & Dochcn (2011) found that when student’s attitude towards mathematics improved they began to see themselves as able to learn math. This also demonstrates that the students were satisfied with the flipped classroom, so much so, that they want their future math classes to be flipped classrooms.

Students in this action research study noted that the lapse in time from when they watch the video lecture until they are asked to apply what they have learned aids in developing an understanding of the concepts. The students were able to think about what they were learning in the video and begin to make sense of the concepts. Gordon (2009) suggests that students in a constructivist classroom should be required to read and think about a new concept first and then present their interpretation to the class. This would allow the students to construct knowledge on their own and provide valuable thinking time as well. Learning occurs when students take the information presented and make sense of it in their own minds (Gordon, 2009) which was supported through the time lapse in presentation and application. The separation of the introduction of a new concept and application of the concept in the flipped classroom provided the students time to engage in the concepts and videos and begin the processing of ideas before collaborating with their group. When taught in a traditional classroom, students do not have the opportunity to process ideas before being asked to apply them and the flipped
classroom provides the space to do that. The flipped classroom allows the students to explore mathematics more deeply than the traditional classroom.

The flipped classroom not only inverted the instructional aspect of teaching but also where the struggling typically takes place for the students. Weinstein (2004) found that students had difficulty understanding the content during class and that the mathematics was not making sense during the lecture in a traditional classroom. He also noted that students struggled to understand the mathematics when they worked in isolation. Students are not given the opportunity to process the incoming information which makes it difficult for students to synthesize and assimilate ideas. This may help to explain why many students struggle to complete the assigned homework which is intended to reinforce ideas from the lecture. The traditional model of teaching caters to a small number of students who learn well this way. Jason noted that in a traditional classroom he would struggle to complete his homework on his own outside of class after the in-class lecture. Jason stated,

In high school I would sit and I would just kind of soak in the lesson and I would go home and try to do the homework that night and I would be like, “I have this question and this question.” Versus I can watch the video, think of questions, then come to class and ask them and have them answered in class.

He implies that when he is doing the work at home and he is having questions, it defeats him because he was not able to ask questions during class (due to trying to “soak in the lesson”) and get those questions answered. As a result he does not complete his homework thereby not reinforcing the learning. However, since there was a gap between the lesson and the application in the flipped classroom the students have time to think of
questions and bring them to class to get them answered. In a traditional classroom students do not typically have the opportunity of thinking of questions because they are still in the processing phase. Whereas in the flipped classroom, students have already moved beyond processing and can advance to application and questioning in the classroom. Also, students now have multiple avenues for assistance. They can ask both their peers and the instructor. This seems to alleviate some of the stress from students. They are getting their concerns met immediately and are not sitting frustrated for hours. It makes it easier for the students to learn because more of the struggling occurs in the classroom as opposed to an isolated environment outside of class.

Collaborative Work in the Classroom

The second component of the flipped classroom, the in-class learning activities supported through collaborative group work, further facilitated constructivism. Students were able to make connections between their lesson preview in the video lecture and the in-class activities. The mixture of those two components of the flipped classroom (video lectures and in-class activities) encouraged the exchange of ideas which supports constructivism. Learning occurs in classrooms from teacher-student interaction, student-student interaction, and personal reflection (Gordon, 2009). The combination of the video lectures in conjunction with the in-class activities encouraged the students to analyze and synthesize their own work and that of their peers in a supportive learning environment.

Students were also noticing that their understanding was further developed when they were forced to explain their constructed understanding to a classmate. Articulation of ideas is vital to developing a mathematical understanding (Fennema, Sowder, &
Carpenter, 1999; Osterholt & Barratt, 2010). The explanations required the students to articulate how they made sense of the concepts which enabled them to continue to build their knowledge of the topic. As students were developing an understanding of the mathematical ideas from the video lectures and the in-class learning activities, they were noticing improvement in their ability to engage in math, leading to greater confidence. The integration of constructivist teaching practices improves student motivation (Pitt & Kirkwood, 2010), self-confidence and helps the students to view mathematics more positively (Wheatley, Blumsack, & Jakubowski, 1995).

**Limitations of Constructivism**

Despite the positive outcomes of the flipped classroom and the integration of constructivist teaching practices, there were students that were unsuccessful. Although students are required to take notes and engage in the video lectures there is no guarantee that students will do either of those. Even if students are watching the video lectures and taking notes, the student may or may not be working to make sense of the concepts and building knowledge. Were those unsuccessful students processing the ideas? Engaging with the videos? Coming to class? Asking questions? Working to understand the mathematical ideas? The flipped classroom is a different culture with different expectations. Were all students able to adopt the skills necessary to learn in a flipped classroom?

Due to the nature of the flipped classroom, students may feel like they are teaching themselves and that the instructor is not adequately doing his job. The traditional classroom has taught students that learning and work occur within the classroom and both activities are led by the course instructor. Requiring students to
engage in lectures outside the classroom may violate their perception of what a classroom looks like, especially since they are expected to assume more responsibility for their learning. It may also seem like additional work to some students since they are now forced to watch the video lectures on their own. In order to thrive in the flipped classroom students must begin synthesizing and analyzing the ideas while watching the video lectures. Students are being asked to learn new material and become independent learners at the same time and some students may not be entering the class with the appropriate skill set to be an independent learner.

Community of Math Inquiry

A community of math inquiry is rooted in constructivism as students are working to create an understanding through dialogue and discussion. Students learn from sharing and listening to the ideas of others and then forming those ideas into a collective understanding (Goos, 2004; Kennedy, 2009; Powell & Kalina, 2009). A community of math inquiry occurs within each student’s zone of proximal development and students are scaffolding each other’s learning through their dialogue (Kennedy, 2009). The flipped classroom helped promote a community of math inquiry as perceived by the adult developmental learners.

Students in this study were noticing that the group work was beneficial because their learning was scaffolded by their peers. Similar to the video lectures, students scaffolded each other’s learning through questioning, clarifying, explaining, and re-thinking (Goos, 2004; Kennedy, 2009). The students were able to quickly and easily ask for assistance, find mistakes, and realize that explaining a concept to their peers forces them to put words to their understanding. When students verbalize their thoughts and
ideas it is helping them build knowledge and create understanding (Kennedy, 2009). Student understanding was evident when they explained their knowledge to a peer. As students were articulating their understanding to a peer, they were relating new knowledge to previous knowledge. For example, Taya used the example of $x$ and $x^2$ to help a classmate understand why $\sqrt{30} + \sqrt{15}$ were not able to be added together. The dialogue and discussion among students was beneficial and supported a community of math inquiry.

Learning occurs when students are engaged in dialogue with those people (teachers and fellow students) in their learning community (Powell & Kalina, 2009; Watson, 2001). Students were benefitting from hearing their peers explain ideas to them and also when they were explaining a concept to their peers. This exchange of ideas helped the students to see different perspectives about solving math problems and thinking mathematically. For example, Sara stated that, “Instead of just getting my own perspective, I am getting everyone else’s perspective and then that helps me because I can think more wide ranged. So I have more ideas to pull from, instead of just my own.” The students were using the perspective of their peers to synthesize with their own understanding and together those varying perspectives were integrated to create a new, more thorough understanding. A classroom that utilizes a community of math inquiry is a learning community where each student is a component in the learning process (Hunter, 2010). The flipped classroom provided the opportunity for everyone in the classroom to become a teaching and learning tool.

The group work in the flipped classroom changed the classroom dynamics by encouraging students to help each other, ask questions and solicit help from their peers.
because it was a less intimidating environment for them. The collaboration also gave the students purpose within their group. They were more likely to work through difficulties and enjoy the group work because they were teaching their classmates. Ava noted, “Once I got comfortable with it, I was more comfortable to talk to my peers about it because I was like – okay, I know how to do this; so if you don’t, I can help you.” It is evident that Ava felt confident enough to help others with their math because she was confident in her abilities and has a defined purpose of helping her peers. This supports what Hunter (2010) found that students became comfortable asking for help, listening to others, and engaging in mathematical dialogue.

Students were becoming so comfortable with their group that many times they only sought me out when everyone was confused. Otherwise, the groups were addressing and solving their own questions and concerns. Goos (2004) found that students in a community of math inquiry became comfortable enough with each other that they didn’t feel the need to involve the teacher in the discussion. They were able to communicate directly with their peers. The students in that study were also comfortable asking the person next to them for assistance or to ensure their thinking was correct. The students in this action research study were exhibiting the same behavior as the students in Goos’ study. Several students noted how they liked being able to check their work with their peers and seek assistance from them. They especially liked that I didn’t hover over them but rather checked in and moved on to the next group.

Additionally, the collaboration within the group work supported the students in developing relationships with each other. Those relationships were founded on their shared struggles with mathematics throughout their educational career. Those shared
struggles allowed the students to bond quickly over their commonality. In the beginning of the semester, the groups began their work by conversing about their dislike for math. Then it progressed to their reminiscing of their high school math experiences, then to how this class was different and finally ending with a bond that allowed the students to trust their group and have the ability to vent about stressful things like mathematics.

The various components of a community of math inquiry (dialogue, discussion, scaffolding, etc.) transformed student perceptions regarding mathematics and encourages understanding. One significant finding that emerged from the data was that students felt they understood what they were learning. All students interviewed mentioned understanding the mathematics. Kristin stated that the flipped classroom is “making me understand it [math] more.” Sara said that, “I am really gaining an understanding for things that I never understood before.” Jason also said that the flipped classroom has “helped me to understand and I think it is much more beneficial than a traditional classroom.” What was it about the flipped classroom in this action research study that made the students feel like they were understanding mathematics? According to Howard and Whitaker (2011), successful students focus on learning for understanding. It seems like an assortment of little things in the flipped classroom were helping transform the students into successful students. The students had the opportunity to think and process individually and on their own terms. Their initial learning was then scaffolded by their peers in a community of math inquiry. Students were also able to go back and engage in the concepts as many times as they needed to. The success and understanding grew from the cohesive unit of the components of the flipped classroom.
Lage et al. (2000) stated that economics classes that incorporate many different teaching styles will increase student motivation and interest in the course as well as enable students to be more successful. The concept central to this idea is that different activities and teaching styles will enable students with different learning styles to be successful. A flipped classroom supports numerous learning styles as there are video lectures, opportunities for collaborative and cooperative work, one-on-one time with instructors, and the convenience of immediate feedback from the instructor and other students. The flipped classroom is advantageous for struggling learners as they can watch lectures as often as necessary and are then given time to process and apply the ideas in an atmosphere conducive to learning.

The environment and atmosphere in the flipped classroom potentially can provide a supportive setting for students, such that in this study several students noted how they are looking forward to taking another math class next semester. For example, Sara began the semester by absolutely hating math and never feeling like she understood but enrolled in three math classes her next semester. In my experience, students that hate mathematics usually avoid it until it is absolutely necessary. Sara is no longer avoiding the subject, she is embracing it. She is so confident in her ability to learn math, that she is tackling three math classes at once. Similarly, Ava is looking forward to her next class,

I’m not as skeptical about math anymore. I’m not going to push away from it. I was afraid because I knew you have to take math in college, especially for certain majors and I was like – I don’t know how I am going to pass in college in any math class if I don’t know how to do anything. Now I am more open-minded to math and more open to wanting to take a math class. I actually schedule[d] a
statistics class for next semester. I would’ve never done that. I would’ve never done that.

Ava’s conviction in her statement above where she says two times, “I would’ve never done that. I would’ve never done that.” indicates a personal transformation and an increased confidence, not just with the mathematics taught, but the confidence and willingness to learn statistics.

Although the students noted that they found the group work beneficial, not all students may echo that same perception. Integrating a community of math inquiry assumes that all students embrace a collaborative work environment. There may be students that are not comfortable working with others and prefer to work individually within a flipped classroom. Due to the structure of the flipped classroom, students are expected to work collaboratively on a daily basis which may inhibit some students’ ability to learn because it conflicts with their learning style and preference.

In addition to the dislike of collaboration, the flipped classroom could be problematic for those learners that do not actively engage with their group. A community of math inquiry purports that learning occurs through dialogue and discussion and the exchange of ideas. However, if students are not participating in the community of math inquiry, it may inhibit their ability to benefit. Active participation is necessary for an effective community of math inquiry as students are scaffolding each other’s learning. Communication is also an important component of this theory of learning. If students are not engaged in dialogue and discussion as well as synthesis and analysis of the ideas, a community of math inquiry assumes that the learner is not learning.
Another limitation to the flipped classroom and a community of math inquiry relates to the ability to ask questions. Since students are engaging in the video lectures outside of class, they are not able to ask questions during the lecture. Due to this shortcoming of the flipped classroom, students are encouraged to bring any questions they had while watching the videos to class. This expectation, however, requires students to be motivated enough to write their questions down. Students may find it threatening to ask questions during class about concepts or ideas that confused them in the videos. The students must be willing to make themselves vulnerable and have the courage to ask their questions in front of their classmates which could be too intimidating for some learners.

**Strengths and Weaknesses of Video Lectures**

At first glance, video lectures do not seem much different than an in-class lecture. However, a closer inspection and a deeper interpretation reveals that video lectures have their own advantages and disadvantages to a lecture during class.

An in-class lecture only affords students one limited opportunity to engage in that specific lecture. Unless the student is audio (or video) recording a lecture, they have no means to engage with that specific lecture again. The in-class lecture occurs in real time and is a once and done commodity. If a student begins to engage in thought about a concept or idea while the lecture is being delivered, they may miss what is being conveyed next because the brain is attempting to multi-task by listening, thinking, and writing about the lecture. Students may be losing information while participating in a live lecture.

Video lectures differ from in-class lectures in that students have the ability to stop and start the video to allow them time to process and engage without missing additional
concepts. The video lectures are an enduring type of teaching because students have the luxury of returning to that information to listen and learn as often as necessary. Students have the ability to rewatch the lecture without competing distractions such as taking notes. A video lecture may also remove some fear and intimidation for students. For example, students may be uncomfortable interrupting a professor to ask them to stop or slow down during a lecture to enable the student the opportunity to finish their note taking or processing of the concept. That type of fear and intimidation is not present in the video lectures as students can stop it and start it at their leisure.

Although there are advantages to a video lecture, there are also disadvantages to this delivery method. Video lectures may eliminate fear and intimidation but they also eliminate the student’s ability to ask questions immediately while engaged with the concept. Unless students are writing their questions down and bringing them to class, it is likely those questions go unanswered. Secondly, students are not able to hear questions that may be raised by their peers during a lecture. In my experience, questions raised by other students are usually beneficial to everyone and highlight something that another student could have overlooked and/or just did not think of yet.

Both video lectures and in-class lectures require an instructor to plan lecture content. The video lectures that I created were very purposely designed for my at-risk population of students. I used my experience teaching developmental mathematics to anticipate questions and misunderstandings that students typically make and attempted to address them in the video. Unfortunately, I am unable to predict all the concerns that students may have. However, an instructor is able to incorporate spontaneity within an in-class lecture and tailor explanations and work to the audience at that moment in time.
In other words, in-class lectures are fluid and can be changed to meet the needs of the students within the class.

Faculty teaching with video lectures may want to consider modifications and/or adaptations to address some of the critique above. Since students are unable to ask questions during their engagement with the lecture, perhaps one way to mitigate this concern is to create a blog or discussion board. A blog or discussion board would allow the students the opportunity to state their questions while participating in the lecture. These online tools would enable students to view the questions of their peers as well as the responses, which could be contributions by both the instructor and the students. Students could also be required to bring one or two questions to class every day. Class could begin with active collaboration within their groups addressing questions from their peers. Questions that would benefit the entire class could be shared and whole class discussion could also take place.

*The Educator’s Role in the Flipped Classroom*

The data collected from this action research study demonstrated that the flipped classroom can be implemented successfully within developmental mathematics and that the students found the experience beneficial to their learning. However there seems to be a factor significant to the success or lack of success within a flipped classroom that is overlooked in the literature. That factor is the role of the educator in the classroom and the impact of the educator on the environment and learning, regardless of teaching methodology or learning strategies. The teacher is a unique element in the partnership with the students in the classroom.
The data revealed in this study that the students embraced my presence in the classroom. Student comments on the free response portion of the faculty evaluations noted: “She always has great enthusiasm to teach students. She makes learning math desirable and allows students to learn in their own way. A great woman and professor.”; “She works with her students. At first I didn’t realize what she was doing until now. She creates an environment for students to pass not to fail. She was a great teacher and I learned a lot.”; “At first I wasn’t excited about this but she was the best math teacher I ever had. I learned so much this semester and understand math.” According to student comments, it seems as though a teacher’s presence has a significant influence on learning. This raises the question, is it the flipped classroom, my presence, or some combination of both that has contributed to the change in attitude concerning math among these students? Or is there possibly something about the flipped classroom that provides a context for promoting a positive relationship with students?

I believe it is related to my classroom philosophy which I adopted shortly before stepping foot into my first classroom in the public school system. I was presented with Haim G. Ginott’s quote (This quote has followed me throughout my 17 years of teaching and can always be found on my desk.) in one of my undergraduate teaching classes,

I’ve come to the frightening conclusion that I am the decisive element in the classroom. It’s my personal approach that creates the climate. It’s my daily mood that makes the weather. As a teacher, I possess a tremendous power to make a child’s life miserable or joyous. I can be a tool of torture or an instrument of inspiration. I can humiliates or humor, hurt or heal. In all situations, it is my
response that decides whether a crisis will be escalated or de-escalated and a child humanized or dehumanized.

I have sat in classrooms where I witnessed the power a teacher possesses and how they were able to positively or negatively impact their students. At one time or another, my experience in education was made miserable or joyous, tortured or inspired, humiliated or healed. I decided at the beginning of my teaching career that I aspired to be the positive in all the situations indicated in the quotation above.

I am passionate about teaching and committed to developmental students. This passion stems from the common threads of struggle and disadvantage shared between me and my students. I was the first in my family to attend college and I share that information as well as the struggles I had with my students. The commonality of struggle shared between the students and myself allows the students to identify with me as someone who escaped educational marginalization. I am able to earn the students trust through their identifying with me. The trust they gave me helped them in taking risks in their learning. They were willing to try something new, such as the flipped classroom, because I was with them supporting them in their learning. The shared trust created a supportive, risk taking environment where students became confident, empowered, and independent.

Several students noted in their interviews that they previously had unsupportive faculty members whom they did not trust. For example, Ava noted,

I was always afraid to ask, and I felt like I lost confidence with math because of the type of people I was in the room with and the environment, and the type of teachers I had, they weren’t really supportive. I lost all confidence.
Ava indicates an unsupportive faculty member as a reason for her lack of confidence in learning mathematics. Sara also discussed her previous negative experience with a teacher,

I remember my senior year when I started Trig, I walked into the classroom – my teacher said, and “I am going to have at least one crier in this classroom.” The person right in front of me was the guy he chose to be the crier – I was right behind him and I was like... I was like trying not to cry. I think that is a good part of why I hated math so much, because of teachers like that... for 12 years.

There is just such a deficit in my school district of math in general.

Sara noted how that teacher created an intimidating and fearful atmosphere. Clearly there was a negative relationship between the student and faculty. It appears that if students do not have a positive, trusting relationship with faculty the student struggles to learn, they learn but hate the class, or they do not learn and they hate the class. Sara discussed a negative relationship that impacted her learning for over a decade. An important ingredient to learning seems to partially stem from the relationship the student and the teacher have. If the relationship is negative it may impact the student for years to come. It also shows that one teacher that is supportive and trustworthy can turn around a decade of mistrust.

Students that do not trust their teacher may experience difficulty learning in the flipped classroom. Those students may be more dependent and may not be prepared to learn in this new environment. Students experiencing that negative relationship with their teacher may not be comfortable taking the risk and learning in a flipped classroom. All data collected in this study revealed that the students felt they were part of a positive
environment. I exerted kindness and compassion while maintaining boundaries to create an environment conducive to learning. My teaching presence appears to have permeated the flipped classroom and impacted its success.

**Quantitative Findings**

The quantitative findings presented here resulted from the faculty evaluations administered at the end of the semester. Student opinions in the faculty evaluations were similar (between the flipped class and traditionally taught classes) on the questions that rated me as the instructor (questions 2 – 9). Closer examination of student opinion of the course (questions 10 – 14) demonstrated that the flipped classroom was successful in helping the students to learn mathematics. Question ten asked the students how they felt the course helped them to progress in the comprehension of terminology and other factual knowledge. More than 88% of the students in the flipped class rated the course as very high in that category while 57.1% of the students in the traditional classes rated the course very high. Based upon these results it would seem that the flipped classroom was successful in helping the students reach a higher level of understanding than students in a traditional classroom. Students repeatedly noted in the end of semester interviews that they felt that they understood the mathematics and gained mathematical knowledge. Although faculty evaluations support student statements during the interviews, the data does not tell us what aspects of the flipped classroom most supported the development of understanding or whether it was the combination of all components of the flipped classroom.

The following survey question, knowledge of fundamental theories and principles, demonstrated a large difference between the flipped class and traditionally
taught classes. Greater than 83% of the students in the flipped class rated the course very high in this question while 61.9% of the students in the traditional class rated the course very high. These results demonstrate that the flipped classroom helped the students to gain a better understanding of the mathematical theories and principles. Perhaps the ability to engage in the lectures at a pace comfortable for the students, or the ability to rewatch lectures, or the collaborative group work assisted the students in gaining this knowledge.

Students in the flipped class also expressed large differences in their ability to apply course material to improve problem solving skills. More than 88% of flipped class students rated the course very high in this category while 66.7% in the traditional classes rated the course very high. Did the communication required within the groups help to teach the students problem solving skills? Again, the data does not tell us what aspects of the flipped classroom helped students to develop problem solving skills but it does tell us that students in the flipped classroom were definitely more confident in this area.

Another significant difference occurred in question fourteen, enhancement of communication skills, where more than 88% of the students in the flipped class rated the course very high while 59.5% of students enrolled in the traditionally taught classes rated that course as very high in this same category. The data seems to tell us that the in-class collaboration was pivotal to this rating. Students were expected to work together every day during class and this requirement helped students to develop their mathematical communication skills. Numerous students commented during the interviews that they found it beneficial to listen to the explanations of their peers because they were exposed to various perspectives. The students also noted that it was beneficial for them to explain
their knowledge to their peers because it forced them to put words to their ideas and it helped them find and correct their own misunderstandings. It is evident that a community of math inquiry was developed within the classroom and that it benefitted the students by enhancing their communication skills which is unique in this classroom.

The final important factor of the faculty evaluations concerns question sixteen. More than 94% of the students in the flipped class rated the course as excellent while 47.6% of the traditionally taught classes rated that course as excellent. This is compelling when you consider that only 44.4% of the students in the flipped class rated their interest in the course as very high while 35.7% of the students in the traditionally taught classes rated their interest in the course as very high. The data illustrates that while almost half of the students in the flipped class were not interested in the course, they left the course very satisfied and almost all of the students rated the course as excellent. Student interest in the course grew significantly until the end of the semester. In comparison though, more than 35% of the traditionally taught students were very interested in the course and not quite half of the students rated the course overall as excellent. The amount of change in perception in the traditionally taught classes was not nearly as significant. It is evident that the flipped class was extremely satisfying for the students and effectively changed student perceptions about the course. Subsequently, despite the small decreases in the number of students that agreed and strongly agreed in the weeks four and ten surveys, student rating at the end of the semester, demonstrates the effectiveness of the flipped classroom.

As with the other quantitative findings, it is difficult from these findings to target the components of the flipped classroom that encouraged such change for the students. It
would be beneficial for future research to investigate which aspects of the flipped classroom helped students to understand, gain knowledge, problem solve, and build communication skills.

Implications for Practice

The findings of this action research study offer several implications for practice. The implications for developmental mathematics will be discussed followed by the implications for the practice of adult education.

*Developmental Mathematics*

Deciding to transition from traditional teaching into a flipped classroom is a significant change. The flipped classroom is labor intensive in the beginning so it is imperative to start small and begin by planning. However, with proper planning, the workload can become manageable.

First and foremost, faculty thinking of implementing a flipped classroom must decide if they are going to make their own videos or use videos created by others. Either way, it will be time consuming in the beginning. If premade videos are the avenue that is deemed the best fit, searches will need to be conducted to find videos appropriate for each curriculum topic. After the videos are found, I recommend storing them somewhere for easy access by the students. Sending and/or posting the links to the videos may be inhibitive for faculty as well as visiting numerous different websites to access videos created by several different people using different formats and mediums may be inhibitive for students.

If faculty decide to create their own videos, I suggest trying out different types of technology and software. Prior to this study, I used several different methods and
techniques until I found Camtasia software with SMART notebook as the one that was the best fit for me. There will most likely be a learning curve for whatever video creation techniques are chosen by the faculty member. Create at least a week’s worth of videos to provide flexibility in the production schedule. Solicit feedback from the students after they watch some of the videos. Their input and suggestions have the potential to help improve the video production.

The video lectures helped to facilitate the flipped classroom because they freed up class time for other learning activities. Students were initially nervous about the video lectures but they ended up finding them pivotal to helping them learn. Since students do not have the ability to ask questions and get them answered while engaging in the videos, organize the information into manageable chunks to scaffold the learning. According to student input, the video lectures need to go step by step and include thorough explanations to help them learn and should be short (less than 10-12 minutes) to keep them engaged and motivated. I question whether students will watch several videos a week if they are over 12 minutes. The video lectures also need to be easily accessible so students can utilize them when it works best for them since this demographic of students were busy and had numerous constraints on their time. As this generation of students is accustomed to multi-tasking, encourage them to watch the videos on their cell phones. If they are watching the videos on their phones, they are less likely to be text messaging, talking on the phone, checking Facebook and engaging in a host of other distracting activities while watching their video lectures for math. Those students that do not watch the videos will be lost in class. In an effort to hold the students accountable for watching the videos, determine a method for assessing the video engagement. I chose to do a
visual check on the notes, but would like to move to an online quiz so I can completely focus my attention on the students and learning during class.

This study yields another implication for developmental educators interested in implementing a flipped classroom. The video lectures were one significant component of the flipped classroom and were more than just a lecture. They helped the students get in the routine of doing math every day and continually reinforcing mathematical ideas. The video lectures allowed the students to speed up the learning or slow it down. They were able to work at their pace and not that of the instructor or their classmates. In addition, the students were able to watch the video lectures as many times as they needed to understand the concepts. Not only could students watch them as many times as they liked but they also used them as a study tool to relearn information to assist with homework, and study for quizzes and exams. Students were able to use the video lectures to attend class as many times as they needed to be successful.

Another important implication for developmental mathematics is that it feels like class time is more productive. Class is now devoted to active engagement with numerous activities rather than passive listening and copying notes. Data showed that students are interested in a more active classroom. Both Jason and Kristin valued the more active classroom as opposed to the passive environment they seemed to be more accustomed to because Kristin said, “instead of watching you do it” and Jason noted that, “we weren’t spending the whole class lecturing and taking notes.” Kristin noted during her interview that the flipped class was better because, “it wasn’t just sitting there lecturing the whole time being bored. It was more hands on, and like – you weren’t just sitting there the whole time.” Developmental learners want more than what we have been giving them.
The in-class learning activities are another implication developed from this study. The learning activities need to be productive and endorsed by the students. It is important to develop in-class learning activities in advance so the instructor has them available to utilize when necessary and appropriate. This action research study found the Problem of the Day (POD) to be the most helpful and productive in-class activity and the most supported by the students as they all mentioned it in their end of semester interviews. Also, the PODs did not use as much time as other activities. Regardless of what type of in-class activity is used, create time limits for each one to keep the students motivated and on-task.

Although the flipped classroom environment is more relaxed than a traditional classroom, it still needs some structure to it to maintain progress. My course calendar provided the underlying structure as that was the guide for the students to know what was going to be addressed in-class and when all assessments would occur. Although there is some structure to the course, faculty should be flexible enough to make change to better meet the needs of the students. For instance, I used to begin class with the PODs to get the students settled and immediately on-task. However, on quiz days, students requested the PODs be moved to right before the end of class quiz because the PODs helped the students to prepare for the quiz.

Faculty should not only be flexible with in-class activities but also with allowing students to choose their own groups to work. It will be challenging some days attempting to balance the different working rates of each of the groups, every day will not go smoothly. Faculty should be comfortable with intervening when groups become off-task and be prepared with positive requests to redirect and refocus attention. Some days,
faculty may need to interrupt the learning activities and do formal teaching during class.

I recommend having the students complete a couple (1-3) of homework problems and bring them to class. Perhaps use three completed homework problems as the students’ ticket in the door. Several students mentioned in their interviews that they began the homework after watching the video lectures. Those students that began their homework prior to in-class activities appeared to be more prepared during class and did not struggle as much as the learners that simply watched the video lectures and took notes.

Another implication for developmental mathematics is a positive, supportive instructor for developmental students. The instructor must be accessible, available, and needs to assist students in developing relationships with each other and the instructor. While students are working on their learning activity, they need an instructor that circulates and offers assistance when needed. Students specifically noted that they liked an instructor that was available for assistance when needed but at the same time did not hover over their shoulder watching their every move. It is also beneficial if the instructor can try to anticipate errors or missteps the students might make and address them in the videos. Although not related to the flipped classroom, the students repeatedly noted the additional learning aids (brain dumps, course calendar, concept maps, and daily homework) were helpful.

**Implications for Adult Learners**

This study also has implications for the field of adult education. In education today, adults have increasing demands on their time and spend very little of their time on campus (Donaldson, 1999). The flipped classroom may be highly suited to the needs of adult learners in higher education. As the findings in chapter four illustrated, the flipped
classroom creates a mobile and flexible learning environment that can be accessed when it is convenient for the learner. The video lectures allow the students to choose their learning atmosphere. If they like to have people around them they could study at Dunkin Donuts. If they prefer a quieter environment they can go to the library with their headphones. If the student only has ten minutes before picking their child up at soccer practice they can watch it on their phone while waiting in the car. Part of the flipped classroom is mobile and the student has the luxury of choosing the environment that suits their learning.

The adult learner also has the luxury of learning at a pace that is comfortable for them and utilizing the video lectures as often as they feel is necessary. In addition to the pace, the video lectures are available when other supports, like faculty and peers, may not be. The flipped classroom allows the adult learners to be independent and provides time for them to process the mathematical ideas.

The flipped classroom may assist adult learners in acclimating to the higher education environment. Many adult learners are reluctant to enter higher education because they are unsure of their ability to handle college level work (Askham, 2008). They also lack confidence in their ability to learn (Kasworm, 2005). The flipped classroom has the potential to ease the adult learners concerns and apprehensions because it changed the student’s perceptions regarding learning mathematics.

Another implication for adult learners is related to the scaffolding of their learning through instructor presence and assistance. The students noted that they did not need an instructor that hovers over them creating an intimidating environment. They were thirsty for something new to help them learn. The students made it clear that they needed
someone who will give them the basics and then provide time and space for them to develop their own understanding. They became empowered and made it clear that if they needed additional assistance that they would let the instructor know. They wanted to be challenged to learn mathematics independently. They seemed to be defining the scaffolding boundaries in regards to the instructor’s presence and assistance within the classroom.

Limitations & Suggestions for Future Research

This section will discuss the limitations presented in chapter one and provide suggestions for future research.

Limitations

Limitations of this study were addressed in chapter one. Two of those limitations will be revisited here. The first limitation was the position of power possessed by me as the course instructor and researcher. Since the course instructor is ultimately the individual that awards course grades at the end of the semester students may not have been truly honest for fear that their opinion would adversely affect their course grade. This limitation was mitigated by establishing a climate of mutual respect within the classroom. On the first day of the semester, class was begun by shaking each student’s hand and introducing myself to each one of them and working to learn each student’s name within the first two weeks of class. In an effort to create a comfortable relaxing environment, we rearranged the classroom into groups on a daily basis. Rather than standing at the front of the room throughout class my role was to continually circulate throughout the groups so as not to intimidate the students by looking over their shoulders.
Time was respected and class did not begin until the exact time and every effort was made to end on time.

The group work required me to be an active listener and pose open-ended questions to the students. Constructive criticism was offered when appropriate and behavior was respectfully redirected when needed. Students were free to converse with their classmates and myself during class. Students were encouraged to discuss any concerns they may have with me at any time. The classroom was designed to be a trusting environment within the classroom. One student had the courage to ask permission to use a brain dump paper (sheet of paper to write anything the student feels they need to be successful on the assessment) on their upcoming factoring trinomials quiz. Normally brain dumps are only allowed on the exams. Students were permitted to use the brain dump for the quiz (3x3 post-it) because one student had the courage to ask and presented a sound argument for her position.

Suggestions for Future Research

This study contributes to the body of knowledge for developmental mathematics, developmental education, and adult education. It has provided knowledge and insight into action research within developmental mathematics and adult education. This action research study answers specific questions regarding the flipped classroom within developmental mathematics.

This study was very context specific as it occurred in a one section of Intermediate Algebra at a public four year institution in the northeastern United States with a minimal number of adult students. Future research endeavors could research the use of the flipped classroom in other environments such as community colleges or adult
basic education programs. Replicating this study in a setting with a larger adult population would be beneficial since the majority of participants in this study were primarily young adults. Since this study was limited to one section of a developmental mathematics course, other studies might include implementing a similar action research study in college level mathematics or implement the flipped classroom in other developmental mathematics courses. Additionally, a comparative study between the flipped classroom and traditional teaching would be useful in providing more insight into this method of teaching.

Personal Reflection

As I reflect back upon this action research study as well as the larger picture of the doctoral program, I realize that I began the program for all of the wrong reasons. At the beginning of the program, I disliked all aspects of research. I often wondered how “armchair theorists” could design and conduct research on myself and my students and seem to know what was best for us. What experience and insight do researchers removed from the context of the study have that will benefit that which is being studied? That concern prompted the action research methodology employed here because I felt that my nine years of practical developmental classroom experience coupled with my passion for what I do would provide valuable insight that a researcher may not possess. Now as I am seeing the light at the end of a very long tunnel, I have come to realize that this is not a “me” and “them” when it comes to research. It is only an “us.” This study has changed my perception of research and my role within it.

Rather than viewing research with the apprehension and trepidation that I had at the beginning of the program, I have come to appreciate the research process. I have also
realized that I need to think beyond my own classroom. The difference between pre-
program/study and now is that I am planning for the future and am looking forward to
engaging in additional research with a few ideas waiting to be developed. Although I
have grown and developed throughout this journey, I realize that I still have so much
more to learn. Nevertheless, I am privileged to call myself a novice researcher and am
inspired to further develop my research abilities and projects.

Another epiphany I have had throughout this study was the acquiescence and trust
my students so willingly gave me at the beginning of the study when we were virtually
strangers. It almost felt unfair to ask students for their informed consent on the second
day of class when all they had was one encounter with me. However, there was an
urgency in the study to secure the informed consent so that data collection could begin. I
felt honored and humbled, almost as though I was given a sacred gift. It was important
for me to make sure that I was a good steward of my students trust. I feel that I was able
to handle that trust responsibly and am hopeful that the students would agree. As Pablo
Picasso once said, “The meaning of life is to find your gift. The purpose of life is to give
it away.” This affirmed for me that teaching developmental mathematics is part of my
purpose in life.
APPENDIXES

Appendix A

IRB Approval

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Date: July 28, 2014

From: The Office for Research Protections - FWA#: FWA00001534
Toplac L. Kahler, Compliance Coordinator

To: Tara E. Diehl

Re: Determination of Exemption

IRB Protocol ID: 44966

Follow-up Date: July 27, 2019

Title of Protocol: FLIPPING THE DEVELOPMENTAL MATHEMATICS CLASSROOM: AN ACTION RESEARCH STUDY

The Office for Research Protections (ORP) has received and reviewed the above referenced eSubmission application. It has been determined that your research is exempt from IRB initial and ongoing review, as currently described in the application. You may begin your research. The category within the federal regulations under which your research is exempt is:

45 CFR 46.101(b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Given that the IRB is not involved in the initial and ongoing review of this research, it is the investigator’s responsibility to review IRB Policy III “Exempt Review Process and Determination” which outlines:

- What it means to be exempt and how determinations are made
- What changes to the research protocol are and are not required to be reported to the ORP
- Ongoing actions post-exemption determination including addressing problems and complaints, reporting closed research to the ORP and research audits
- What occurs at the time of follow-up

Although not necessary for the PSU IRB Exemption Determination, you will want to verify with the Bloomsburg University IRB that they will/will not want to review your research project separately since the research is being conducted on their site.

Please do not hesitate to contact the Office for Research Protections (ORP) if you have any questions or concerns. Thank you for your continued efforts in protecting human participants in research.

This correspondence should be maintained with your research records.
Title of Project: *Flipping the developmental mathematics classroom: An action research study*

Principal Investigator: *Tara Diehl*
*Bloomsburg University*
*Department of Developmental Instruction*
*SSC 038*
*tdiehl@bloomu.edu*
*(570) 389-4554*

Advisor: *Edward Taylor, Ed.D., Professor of Adult Education*
*Penn State Harrisburg*
*W314 Olmstead Bldg.*
*ewt1@psu.edu*
*(717) 948 - 6364*

You are being invited to volunteer to participate in a research study. This summary explains information about this research.

**Purpose of the study:** The purpose of this research is to explore a flipped classroom with developmental mathematics students. A flipped classroom utilizes educational videos to provide preliminary instruction outside of class and transforms in-class time from listening to lectures into time for students to process the mathematical ideas and concepts in a supportive learning environment. This will require students to watch and engage with the lectures outside of class and come to class prepared to apply what they are learning in the video lectures created by the Principal Investigator. Classes that are flipped will be held the same amount of time as traditional classes.

**Procedures to be followed:** This study is designed using an action research methodology which means that it will be constantly evolving and be shaped to meet the needs of the participants. Feedback from the participants will enable the Principal Investigator to work towards improving success in developmental mathematics for underprepared students. The participants will be asked to provide data that will be collected over the 15 week semester from surveys, faculty evaluations, and interviews. The surveys will take place at the beginning and mid-point of the
semester. Interviews will be completed within the last two weeks of the semester and will take no longer than 60 minutes. They will be audio-taped and transcribed. Faculty evaluations will be conducted at the end of the semester. The surveys, interviews, and faculty evaluations will not be graded.

Discomforts and risks: There are no risks in participating in this research beyond those experienced in everyday life. Participation or non-participation will not have any effect on your grade for the class or any known effects.

Duration/time of the procedures and study: This study will be conducted within a single academic semester.

Statement of confidentiality: All of the information collected during this study, including any information that directly links you to the study or identifies you, will be kept confidential. Randomly selected code numbers will be used for all participant data. No personal numeric data (i.e. social security numbers, birthdates, telephone numbers, etc.) will be used to identify participants. Any coded information that may identify your identity will be destroyed immediately after the dissertation defense. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The collected data will be stored and secured at the Principal Investigator’s home in a locked file cabinet and password protected files on her computer. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University’s Social Science Institutional Review Board, and Penn State University’s Office for Research Protections.

Option for the use of coursework: May the Principal Investigator use your coursework, responses to surveys, or other information for research purposes? Please choose one response:

_____ I DO give my consent to have my work included in the study.

_____ I DO NOT give my consent to have my work included in this study.

Option for tape recording: May the Principal Investigator audio tape the interviews conducted within the last two weeks of the semester? Please choose one response:

_____ I DO give my permission to be audio/digitally taped.

_____ I DO NOT give my permission to be audio/digitally taped.
If you have questions or concerns, you should contact Dr. Edward Taylor at (717) 948-6364 or ewt1@psu.edu. If you have questions regarding your rights as a research subject or concerns regarding your privacy, you may contact the Office for Research Protections at 814-865-1775.

Your participation is voluntary and you may decide to stop at any time. You do not have to answer any questions that you do not want to answer. You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below. You will be given a copy of this consent form for your records.

_______________________________________  ___________
Participant Name (Please print)    Date

_______________________________________  ___________
Participant Signature      Date

_______________________________________  ___________
Person Obtaining Consent     Date
Appendix C

Beginning of Semester Survey

1.) What is your gender?  Male  Female

2.) What is your race?  (Circle one)
   Caucasian
   African-American
   Hispanic
   Asian
   Native American
   Other (please specify)____________________

3.) What is your age?  __________

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<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.) Did you enter Bloomsburg University in the same calendar year as graduating from high school?</td>
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<tr>
<td>5.) Do you attend Bloomsburg University part-time?</td>
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<td>6.) Do you work full-time (35 hours or more) while enrolled at Bloomsburg University?</td>
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<td>7.) In terms of financial aid, are you considered independent?</td>
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<td>8.) Do you have dependents other than a spouse?</td>
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<td>9.) Are you a single parent?</td>
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<tr>
<td>10.) Did you earn your high school diploma?</td>
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</tbody>
</table>
| 11.) If you answered “no” to question 10, did you earn your GED or completion certificate?  
      (Horn & Carroll, 1996) |

12.) When you hear the word mathematics what comes to mind?

13). What has been your experience of learning mathematics in a classroom?  
    Describe some of your successes and challenges.

14.) What do you find to be the most helpful when learning mathematics?
# Appendix D

## In-class Learning Activities

<table>
<thead>
<tr>
<th><strong>Strategy</strong></th>
<th><strong>Grouping</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Analysis</td>
<td>Individual, Pairs, or Group</td>
<td>Provide students with appropriate worked problems that contain one or more errors. Students are required to locate and correct the error.</td>
</tr>
<tr>
<td>Notes Comparison</td>
<td>Pairs</td>
<td>Students compare their notes from the video lectures to evaluate the accuracy and to determine if they are missing important information.</td>
</tr>
<tr>
<td>3 Questions from Homework</td>
<td>Pairs or Group</td>
<td>Students begin working on three questions from their assigned homework. These can either be selected by the instructor or the students.</td>
</tr>
<tr>
<td>Roundtable Exercise</td>
<td>Group</td>
<td>Provide each group with one or more math problems. The first person completes the first step of work then passes the problem to the next person. The second person completes the second step of work and passes the work to the third person. This process continues until the work is finished.</td>
</tr>
<tr>
<td>Informal/Ungraded Quiz/Exam Questions</td>
<td>Individual or Pairs</td>
<td>Provide students with an informal/ungraded quiz to check for understanding. Students “grade” their own work.</td>
</tr>
<tr>
<td>Predict Quiz/Exam Questions</td>
<td>Individual, Pairs, or Group</td>
<td>Students compile a list of potential quiz/exam questions.</td>
</tr>
<tr>
<td>One Question from Video Lecture</td>
<td>Individual, Pairs, Group, or Class</td>
<td>Students bring questions from video lectures to class. Questions can be addressed within the groups and presented to the class and instructor.</td>
</tr>
<tr>
<td>Minute Paper: “What You Didn’t Understand?”</td>
<td>Individual</td>
<td>Students complete a short write on what they didn’t understand.</td>
</tr>
<tr>
<td>Jigsaw</td>
<td>Group or Class</td>
<td>As an exam review, students are assigned a different objective or “type” of problem. They relearn that objective and then change groups and ensuring that each group contains members with different objectives. Each student then re-teaches their objective to the new group.</td>
</tr>
<tr>
<td>Thought Provoking Questions</td>
<td>Group</td>
<td>Provide students with thought provoking questions to discuss in their groups.</td>
</tr>
</tbody>
</table>
Appendix E

Week 4 & 10 Survey

Place an “X” or checkmark in the appropriate column. Use the following scale to answer questions 1 – 8 below:

1 = strongly disagree
2 = disagree
3 = neutral
4 = agree
5 = strongly agree

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>1.) The video lessons have good sound quality.</td>
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<td>2.) The video lessons have good problem illustration.</td>
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<td>3.) The video lessons are well explained.</td>
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<td>4.) The video lessons are easy to access and watch.</td>
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<tr>
<td>5.) The in-class learning activities are helping me to learn from my peers.</td>
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<td>6.) The in-class learning activities reinforce the topic.</td>
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<tr>
<td>7.) I enjoy participating in the in-class learning activities.</td>
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<tr>
<td>8.) The in-class learning activities provide the opportunity for more feedback from my peers and the instructor.</td>
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</tbody>
</table>

9.) What changes would you suggest for the video lessons and why?

10.) What changes would you suggest for the in-class activities and why?

11.) Questions? Comments?
Appendix F

End of Semester Interview

1.) How do you feel about learning math? What you like? What do you dislike?

2.) What has been your experience of learning math in this course?

3.) What is your reaction to the flipped classroom design?

4.) What have you found helpful in the course this semester? What have you found to be a challenge?

5.) How do you see the out of class work and the in-class work related?

6.) What part(s) of the flipped classroom do you find most helpful? Least helpful?

7.) Describe your experience of using the videos? Sound quality? Illustrations? Ease of access? Pace? Length?

8.) Did you use the videos in any other time besides when they were assigned for class? If so, how?

9.) Describe your experience working in small groups and learning in collaboration with your fellow students.

10.) What did you find challenging about working in the small groups?

11.) What about my role during the in-class activities?

12.) Overall, what is your impression of the flipped classroom?

13.) If you had a friend who was about to enroll in a flipped classroom for math what would you tell him or her?

14.) How did the flipped classroom impact your mathematical learning this semester? Did it help or hinder? Why or why not?
15.) Describe how the flipped classroom has changed or not changed your perception of learning mathematics.

16.) How does the time lapse between the video and class compare with the traditional classroom learning “learn and immediately apply?”

17.) What was the environment/atmosphere like in the flipped classroom?

18.) Would you like to continue learning math in a flipped classroom? Why or why not?

19.) At the beginning of the semester, I only flipped Wednesday’s class, and then in weeks 3-4, I flipped Monday and Friday. It wasn’t until week five that I actually began flipping every day. What is your reaction to that transition at the beginning of the semester? Did you like it? Do you not like it, would you recommend it? Would you say, “Hey, flip everything from the beginning?”

20.) Was the level of responsibility for you as a student more or less manageable in the flipped classroom?

21.) Did you see the learning in the flipped classroom as more independent, dependent, or a combination of both of those?

22.) Is there anything that you learned in the flipped classroom that you will take with you beyond this semester?
Appendix G

Faculty Evaluations

Bloomsburg University
Faculty and Course Evaluation Form

Specify YOUR ORIGINAL MOTIVATION or DESIRE to take this course.
(A) Very high (B) High (C) Moderate (D) Low (E) Very low
1. My initial interest in the content of this course was… (A) (B) (C) (D) (E)

Specify the frequency with which your instructor used the following TEACHING PROCEDURES.
(A) Almost always (B) Usually (C) Sometimes (D) Almost never (E) Never
2. Showed enthusiasm for teaching. (A) (B) (C) (D) (E)
3. Was prepared for class. (A) (B) (C) (D) (E)
4. Used grading procedures as specified in the course outline. (A) (B) (C) (D) (E)
5. Explained the evaluation of students' performance. (A) (B) (C) (D) (E)
6. Made explanations that were clear and to the point. (A) (B) (C) (D) (E)
7. Conveyed the significance of the subject matter. (A) (B) (C) (D) (E)
8. Facilitated independent thinking and problem solving. (A) (B) (C) (D) (E)
9. Encouraged students to be involved in the learning process. (A) (B) (C) (D) (E)

How has this course helped you to PROGRESS in the following areas?
(A) Very high (B) High (C) Moderate (D) Low (E) Very low
10. Comprehension of terminology and other factual knowledge (methods, trends, …). (A) (B) (C) (D) (E)
11. Knowledge of fundamental theories and principles. (A) (B) (C) (D) (E)
12. Ability to apply course material to improve problem solving skills. (A) (B) (C) (D) (E)
13. Understanding how to gain new knowledge in the field. (A) (B) (C) (D) (E)
14. Enhancement of communication skills. (oral, in writing, or performance). (A) (B) (C) (D) (E)

Rate the COURSE AND INSTRUCTOR.
(A) Excellent (B) Above average (C) Average (D) Below average (E) Poor
15. I rate this INSTRUCTOR as … (A) (B) (C) (D) (E)
16. I rate this COURSE as … (A) (B) (C) (D) (E)
17. I rate the COURSE MATERIALS as… (A) (B) (C) (D) (E)

Bloomsburg University of Pennsylvania is committed to providing equal educational and employment opportunities for all persons without regard to race, color, religion, sex, age, national origin, ancestry, life style, sexual orientation, disabilities, Vietnam era veteran status, or union membership. The university is additionally committed to affirmative action and will take positive steps to provide such educational and employment opportunities. Inquiries may be directed to our Social Equity Director at (570) 389-4528.

Developed by a committee of students, faculty, and management at Bloomsburg University, May 1995.
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Selected Presentations