A Comparison of Instructional Strategies: Does How You Teach Mathematics Matter?

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A COMPARISON OF INSTRUCTIONAL STRATEGIES:

DOES HOW YOU TEACH MATHEMATICS MATTER?

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Brian Comeaux

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Abstract

For most of the twentieth and all the twenty-first century, there has been a great debate over educational reform for teaching mathematics. From these debates have come a critical look at how to properly instruct students so they can actively learn in the classroom, yet still retain the information for use in their later life. These questions are rooted in the larger debate between philosophical and psychological dimensions of human growth and development. Some educators, therefore, believe structuring their instruction around some philosophies such as idealism, realism, pragmatism, or existentialism was the key to success for their students. Others took the psychological approach and featured behaviorist or cognitive ideas in their teaching. Most feel that the approaches to psychology reflect these philosophical and psychological theories. These positions have resulted in the emergence of specific suggested teaching strategies that each proponent believes provide the solutions to the dilemma of how to best educate today’s students. This study examines what effect two different instructional strategies have on student acquisition of mathematical concepts and procedures.

Keywords: Instructional Strategies, Flipped Classrooms, Direct Instruction, Indirect Instruction
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Introduction

Background

Many researchers think that how we teach has the biggest impact on what students learn. There are many ways a teacher can choose to teach a given subject. Two approaches to education have emerged as the most common examples of strategic teaching: direct and indirect (Jahr, 2011). Direct instruction is what is commonly seen throughout the classrooms of North America today, and is what most people have experienced in their lifetime as a student (Committee on Developments in the Science of Learning, 2002; Joyce, Weil, & Calhoun, 2017). Jahr (2011) labels these types of teachers as those who probably begin their class by asking students to “please open your books to page 63” (p. 2). According to Hauser (2004), direct teaching is more teacher-centered when compared to other methodologies. The instruction is characterized by a rapid pace with specified sequence and procedures for instruction. Despite growing concerns about direct instruction, many classroom teachers persist in using it. (Caicco, 2016). According to Markusic (2012), “although direct teaching is one of the most widely used teaching strategies, it has been criticized as ineffective and scorned as the teaching method used by teachers who are not prepared” (Introduction, para. 1). The main criticism of direct teaching is the fact that the students are not the focus of instruction. This is because this strategy consists of mostly lecture, worksheets, and modelling. The entire structure of the classroom is sequential and rigid, which, as Markusic (2012) explains, “hinders the creativity” of the students (Disadvantages, para. 1). Without creativity, students lose the sense of ownership in their education, resulting in inadequate learning experiences (Markusic, 2012).

Indirect instruction, on the other hand, is quite different. McCambridge (2015), states that indirect instruction “seeks a high level of student involvement in observing, investigating,
drawing inferences from data, or forming hypotheses. It takes advantage of students' interest and curiosity, often encouraging them to generate alternatives or solve problems” (What is Indirect Instruction, para. 2). This style of instruction has been promoted by the National Council for Teaching Mathematics (NCTM) (2005). This group proposed changes in learning standards and outcomes, which led to altered learning strategies that took the emphasis away from lecture and focused instead on discovery learning (NCTM, 2005). These reforms, along with the growing prominence of technology in the classroom, resulted in an increase in indirect teaching methods, such as the flipped classroom, in which students take on the role of teaching in the classroom and the educator acts as a facilitator.

**Purpose of the Research**

While research has been conducted to compare direct and indirect teaching strategies, much work remains to be done, especially for understanding the impact that the flipped classroom model may have on student achievement (Caicco, 2016). This is likely due to the issues associated with conducting this type of research, like locating teachers using the flipped method, which was made obvious to the researcher when pooling participants, along with the newness of the flipped classroom strategy. The limited nation-level research projects that have been done on the impact of the flipped learning have only been conducted through private, individual school researchers or students working towards degree requirements (Caicco, 2016). A review of the literature indicates that more information is needed to understand how flipped classrooms impact learning, especially in math education.

The need to understand how these instructional strategies influence student learning is important. This is often reflected in proposals defining the purpose of education, especially math education. Wees (2011), for example, says that “the objective of good math teaching should not
be to ‘cover the curriculum’ but to show students how to explore our fascinating world through the lens of mathematics” (Introduction, para. 1). Because of this, discovering which strategies work to promote this style of understanding and appreciation of mathematics is key. Wees continues by saying that educators “must change our focus in math education” and make “math relevant and engaging for students” (Introduction, para. 1). Comparing these methodologies should yield insights into how each strategy might contribute to this goal as well as highlight the strengths and weaknesses inherent in each strategy.

This research, therefore, was designed to describe and contrast two teaching strategies – direct instruction and the flipped classroom. In order to accomplish this, this study consisted of observation and quantitative assessment to understand how each method might influence student understanding of specific math concepts. These allowed the researcher to analyze student-teacher interactions, student to student interactions, levels of student engagement, and teacher actions in the classroom as well as analyze student performance on varying levels of written mathematical tasks to understand if how you teach mathematics matters.

The research question for this study, therefore, is: What effect do direct instructional and flipped classroom strategies have on student learning activities and performance on objective assessments?

A Review of the Literature

Introduction

In the same way that lessons which are structured to use a direct teaching strategy differ from an indirectly-taught lesson, the history and characteristics of both strategies is also dissimilar. Each method of instruction was born with the hopes of improving the educational experience for students in the classroom, but, as it turns out, each strategy has also been shown to
have negative side effects when implemented (Caicco, 2016; Rosenshine, 2008). Through reviewing the background and qualities of each style of instruction, the methods of data collection in the study can be understood and concluding results of the research can be justified.

**Direct Instruction**

**History.** The term direct instruction was first used in the mid-1970s by Rosenshine after investigating behaviorist strategies used in various classrooms along with the framework created by Engelmann, which included “task analysis and teacher modelling” (Kim & Axelrod, 2005, p. 113). Kim and Axelrod (2005) consider the modern-day direct instruction commonly seen throughout many classrooms in the United States to be a system or conglomeration of procedures and practices that do not precisely have one philosophical basis at their center. Because this approach to teaching is generally a mixture of prior strategies, the initial basis for this type of instruction was implemented for a variety of students who were considered at-risk and were identified with social, emotional, or mental impairments (Becker & Carnine, 1981; Bereiter & Engelmann, 1966; Kim & Axelrod, 2005). According to this research, researchers thought a shotgun style approach to teaching would improve learning for a majority of the at-risk students. Considering the research previously conducted by Rosenshine and Engelmann, along with the principles set forth by the work done with students susceptible to at-risk behavior, a generally universal approach to using direct instruction in the classroom has been developed featuring curriculum organization, educational procedures, student evaluations, and teacher coaching (Joyce, Weil, & Calhoun, 2017; Stein, Carnine, & Dixon, 1998). In terms of math education, this method of instruction has always been a principal strategy for teachers to use in their classroom. Jahr (2011) mentions that because of the progressive studies that were conducted in the educational field in the mid-1900s, like Rosenshine’s mentioned above, the direct approach to
teaching was perfect for the “do more in less time” society (p. 3). This approach is described in the following section.

**Characteristics.** Adams and Carnine (2003) provide a list of the main elements of direct instruction classrooms, which supports descriptions given by Adams and Engelmann (1996), Joyce, Weil, and Calhoun (2017), Rosenshine (1987), and Rosenshine and Meister (1994):

1. Focusing almost all classroom activity on learning basic academic knowledge and skills. Affective and social objectives, such as improved self-esteem and learning to get along with others, are either de-emphasized or ignored.
2. Having the teacher make all instructional decisions, such as how much material will be covered at one time and whether students work individually or in groups.
3. Keeping students working productively toward learning new academic knowledge and skills (usually being on-task) as much as possible.
4. Maintaining a positive classroom climate by emphasizing positive reinforcement and avoiding the use of aversive consequences. (p. 370).

Other researchers have chosen to focus on other aspects of direct instruction. Moore (2014), for example, contends that content in direct instruction is taught in a specific order, like a ladder, with each step up being a new lesson. To have success in the classroom using direct instruction, therefore, there are certain generalized guidelines that must be followed, which include: “a) be clear, b) be efficient, c) teach to mastery, d) celebrate success, and e) beware intuition” (Moore, 2014, p. 38). To be clear, a teacher should be concise with explanations and incorporate both “not learning the wrong rule” as well as “learning the right rule” (Moore, 2014,
p.39). Efficiency is acquired through homogeneous grouping as well as step-by-step explanations, or “algorithms” (Moore, 2014, p. 39). Others also maintain that learning any given subject follows the same idea, as tasks should be broken down and explained in a rational order with constant connections to and strengthening of past learning (Barbash, 2012). While many strategies combine to create the direct instruction strategies seen in many classrooms, in short, direct instruction strategies are simply “clear, accurate, and unambiguous instruction” (Stein, Silbert, & Carnine, 2006, p. 4).

**Teacher characteristics.** It appears that much of the success of this strategy, therefore, relies on the teacher. This makes it important to consider the characteristics of the teacher who chooses to use direct instruction. Jahr (2011) explains that from the teacher’s perspective, “learning by the student is put on the shoulders of the teacher” (p. 2). This author is saying that the teacher is responsible for how and what students learn in any given lesson (Jahr, 2011). Teachers implementing direct instruction in their classroom have also been labelled as teaching “actively” or “explicitly,” which, according to Schug (2003), conveys:

...the image of teachers on their feet in the front of the room with eyes open, asking questions, making points, gesturing, writing key ideas on the board, encouraging, correcting, demonstrating, and so forth. The role of the teacher was obvious and explicit and tied to clearly identified content or skills (p. 94).

Ameliana (2017) also examines the role and portrayal of the teacher in the direct classroom by providing recurrent characteristics of direct instruction educators:
As teachers become the most dominant source of information, in teacher-centered learning, for example, all questions which are raised by students, if any, are answered directly by teachers without students’ involvement. In designing the class activities, teachers control every single learning experience. … In this way of learning the real important thing is to transfer the knowledge to the learners (p. 60).

In a direct instruction classroom, the environment is essentially a teacher-based learning space in comparison to trends found in educational reform from the past two decades, which usually involves student-based learning environments (Schug, 2003). Teachers also have to have a strong content knowledge base in order to foster student learning and adequate skills in assessing student knowledge (Jahr, 2011).

**Testing.** Because direct instruction has been a mainstay in classrooms around the world for years, there has been a vast amount of research done on the impact direct instruction has on test scores (Schug, 2003). It has been inferred that if students perform well on the tests, they must understand the information (Jahr, 2011). Over the past four decades there have been over 30 research studies which compared direct instruction to other teaching techniques (Schug, 2003). In these studies, it was found that “87 percent of posttreatment test score averages favored Direct Instruction, compared to 12 percent favoring other approaches” (Schug, 2003, p. 96). Taking these scores into account:

A meta-analysis of data from the 34 studies also yielded large effect sizes for Direct Instruction. Large gains were reported for both regular and special education students, for elementary and secondary students, and for achievement in a variety of subjects including
reading, mathematics, spelling, health, and science. … This means that gain scores for students in Direct Instruction groups averaged nearly a full standard deviation above those of students in comparison groups (Schug, 2003, p. 97).

In more recent years even more evidence has been uncovered to back the effectiveness of direct instruction (Moore, 2014). For example, throughout the 2011 and 2012 school years Moore (2014) compared test scores of at-risk middle school math students. The study was designed so that one half of students were taught under implemented direct instruction techniques and the other half were taught without any direct instruction interventions incorporated into their lessons (Moore, 2014). His results “suggest the direct instruction mathematic intervention yielded a statistically significant increase in test scores for student participants when compared to students not receiving the intervention” (Moore, 2014, p. 99). Direct Instruction, with its long history and studied practices, has consistently shown to have a positive impact on student test results in research studies (Schug, 2003; Moore, 2014). It should be noted, however, that none of these research projects compared direct instruction to the flipped teaching approach in the mathematics classroom. Despite the apparent effectiveness of direct instruction in raising test scores, other questions have been raised concerning the effect direct instruction could have on other aspects of learning.

**Criticism.** While this style of teaching is thought to improve what students understand because of increases in test scores, there has been some conversation discussing the possible negative attributes of using direct instruction in the classroom. Rosenshine (2008) offers the following descriptors of direct instruction: “authoritarian,” “regimented,” “fact accumulation at the expense of thinking skill development,” and “the pouring of information from one container,
the teacher’s head, to another container, the student’s head” (p. 4). These characteristics are supported by research from other researchers including Borko and Wildman (1986), Brown and Campione (1990), Edwards (1981), and McKeen (1972). The criticisms are based on the lack of student-centered learning environments frequently seen in direct instruction classrooms (Rosenshine, 2008). While advocates of direct instruction may argue that knowing the facts is fundamental in mastering content, the teacher-dependent instruction has been shown to lower student motivation (Ford & Roby, 2013). Using qualitative methodologies and assessing 225 high school students, Ford and Roby (2013) found that when students lack motivation in the classroom, direct instruction can foster a personal belief of adverse abilities, which results in the students disbelieving that they can complete tasks, which can lead to “poor academic performance, low academic self-esteem, and an elevated intent of withdrawing or dropping out of high school” (Ford & Roby, 2013, p. 105-106). Though research has shown test scores are improved by direct instruction, Ford and Roby (2013) would likely argue that the strategy also contributes to negative attributes that can hinder student learning, as they believe learning is more than just a test score.

Indirect Instruction

History. Indirect instruction implemented in the mathematics classroom was born out of the call for reform of standards in 1989 by the National Council of Teachers of Mathematics, or NCTM (Jahr, 2011). Klein (2003) summarizes the proposed changes:

The grade level bands included lists of topics that were to receive "increased attention" and lists of topics that should receive "decreased attention." For example, in the K-4 band, the Standards called for greater attention to "Meanings of operations," "Use of
calculators for complex computation," "Use of manipulative materials," and "Cooperative work." Included on the list for decreased attention in the grades K-4 were "Complex paper-and-pencil computations," "Paper and pencil fraction computation," "Rote memorization of rules," and "Teaching by telling." (The NCTM Standards, para. 3)

The NCTM (2005) not only called for edits to be made for content standards but also put in place principles for student learning that highlighted recommendations for how teachers should teach mathematics in the classroom. The NCTM (2005) specifies that with these principles in mind, teachers can be effective if they can:

...understand deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks. They need to understand and be committed to their students as learners of mathematics and as human beings and be skillful in choosing from and using a variety of pedagogical and assessment strategies. In addition, effective teaching requires reflection and continual efforts to seek improvement. (p. 17)

Jahr (2011) maintains that because of this call for new understanding of mathematics, there has been even more interest in including indirect instructional strategies in math education. This interest in indirect instructional strategies has been fostered by increased global comparisons of student achievement and enhanced by increased technological advances and accessibility of technology in classrooms (Klopfer, Osterwell, Groff, & Haas, 2009).
This increased technology capability and accessibility has also impacted interest in indirect instruction in classrooms (Srivastava, 2014). Changes in how instruction is structured have been even further influenced by the inclusion of technology in the NCTM’s (2005) Principles, Standards, and Expectations, as it called for technology to be added to the classroom experience to enhance student learning. As computers, iPads, and sophisticated calculators have become readily accessible in classrooms, instruction has been restructured making it possible to individualize instruction in new ways (Caicco, 2016). In respect to the students, the added technology was also prescribed to help with problems with routine calculations, which allows them to focus on broader concepts (NCTM, 2005). In recent years, the concept of indirect instruction that relies heavily on individual student work on computers guided by teacher oversight, known as the flipped classroom, is being seen more often.

**The flipped classroom.** For the purpose of this research, the specific indirect strategy to be studied will be *flipping the classroom*, a method of instruction that melds technological progress along with new indirect ideologies to create student-centered learning environments both at home and in the classroom (Srivastava, 2014). Using the home as a location of learning is an important aspect of the flipped classroom that will be discussed in greater detail later. Flipped learning was also chosen as the frequency of teachers flipping their classroom has become so popular over the past few years that the limited research on the effects of the change has already been “outpaced” (Caicco, 2016, p. ii). Caicco (2016) gives a brief history of how flipped learning evolved into a mainstream method of instruction:

The first description in the literature of a flipped classroom is attributed to Eric Mazur (1991), who reported on his experience using computer-based instruction to guide
students through a physics unit outside of class time. He remarked on the increased time available in class for one-on-one interaction with his students. About 10 years later, Lage, Platt, and Treglia (2000) described their experience creating a university-level economics “inverted classroom” consisting of multimedia to be viewed outside of class in a media lab or at home. Importantly, student survey results showed the participating students found the approach to be favorable over traditional teaching due to increased student-teacher interaction, more active engagement, and group collaboration (p. 9).

**Philosophy of the Flipped Classroom.** According to the Flipped Learning Network (2014), the main philosophy behind the creation of a flipped classroom can be broken down into four essential pillars which include: **F**lexible Environment, **L**earning Culture, **I**ntentional Content, and **P**rofessional Educator. The flipped classroom is designed with these principles in mind; these include various learning modes, improved student engagement in learning, increased focus on conceptual understanding, and refined reflective practitioners (Flipped Learning Network, 2014).

The principles put forth by the Flipped Learning Network coincide with the previously mentioned principles suggested by NCTM. For example, NCTM (2005) accentuates the importance of improving student learning by emphasizing conceptual understanding of content. NCTM (2005) explains that:

> One of the most robust findings of research is that conceptual understanding is an important component of proficiency, along with factual knowledge and procedural facility. … A major goal of school mathematics programs is to create autonomous
learners and learning with understanding supports this goal. Students learn more and learn better when they can take control of their learning by defining their goals and monitoring their progress. When challenged with appropriately chosen tasks, students become confident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas and trying alternative solution paths and willing to persevere (p. 20-21).

According to NCTM, therefore, there are more important considerations that just doing well on standardized tests. Flipping the classroom takes the ideas presented and goals afforded by the NCTM to improve learning outcomes by students and addresses the expanded role of technology in the students’ daily lives (Srivastava, 2014).

**Characteristics.** Like other aspects of pedagogy, the term "flipped classroom" can have a variety of interpretations but generally is used to label classrooms where the core content is delivered on the students' own time and space, which is made possible by technology (Srivastava, 2014). Because the instruction is moved from the classroom to the individual's non-classroom learning environment, Caicco (2016) says that the group learning space during class time is converted to offer a "dynamic, interactive learning environment where the teacher guides students as they apply concepts and engage creatively in the subject matter" (p. 25). Srivastava (2014) listed a set of beneficial characteristics commonly found in a flipped classroom, which includes the following:

1. Provide an opportunity for students to gain first exposure to content prior to class.
2. Provide an incentive for students to prepare for class.
3. Provide in-class activities that focus on higher-level cognitive activities.

4. Provide a mechanism to assess student understanding. (p. 81)

Caicco (2016) also found that, while on paper the flipped classroom offers room in the general classroom for ambitious contextual conversations, in reality many teachers often use the time for questioning and clarification of content concepts. Noting that time spent in class could simply be used to review content covered in the at-home work, the claimed increase in conceptual understanding through deeper conversation comes at a lesser degree than expected from the “ideal outcomes of flipping the classroom” (Caicco, 2016, p. 29).

In more concrete terms, in a flipped classroom the students would usually have their own time outside of class to self-pace themselves to complete the general content requirements of their respective classes using some form of technology, either through interactive textbook modules, recorded lessons, or websites (Caicco, 2016; Srivastava, 2014). As a result, in the physical class time, the students are then presented with opportunities to expand their understanding of the topics by “learning various approaches,” and working with the educator to “clarify content, check understanding, monitor progress and provide one to one support” (Srivastava, 2014, p. 82).

**Effects of Student-based learning.** Like in all forms of indirect teaching, in a flipped classroom the students are required to essentially take responsibility to learn the core content, which according to Muir (2016) and Bergman, Overmyer, and Wilie (2013) is ultimately where the instructional model has the most usefulness, as it has the "potential ... for students to achieve mastery of topics as they are able to self-pace their learning" (Muir, 2016, p. 488). Srivastava (2014) states that growth in student understanding of the subject increases as students engage in
organizing new concepts while amending any misconceptions from previous learning. Having the students developing their own methods of learning and understanding "factual knowledge in the context of a conceptual framework" truly allows for them to not only "develop competency in [the] subject," but also fully take control of their own education and experiences in the classroom (Srivastava, 2014, p. 81). This is completely opposite from the teacher-led approach found in the direct instruction classroom, and hence is a substantial characteristic by which to compare the two strategies.

Understanding flipped classrooms also leads to the discussion of motivating students as many educational researchers believe this method of student-based learning stimulates students to engage more in the content (Muir, 2016). Muir (2016) explains that “students’ motivation is related to their beliefs about whether or not they can perform the task and whether or not the task is worth performing,” hence when they have a direct connection with the pace of the material and a personal responsibility for learning, they are more inclined to put their best effort forward (p. 488). Abeysekera and Dawson (2015) found, by analyzing the flipped classroom in respect to the motivation-driven self-determination theory (SDT), the students in flipped classrooms had often increased motivation due to the following classroom components: sense of competence, sense of relatedness, sense of autonomy, tailoring to proficiency, and individual pacing. Muir (2016) evaluates and endorses their findings as further confirmation that flipped classrooms do indeed foster more motivated students. Muir (2016) explains:

In their theoretical model, students develop a sense of competency through a belief that they can perform a task, are motivated to perform the task if they can relate to it as being
important and interesting and are more likely to complete the task if they have a sense of autonomy or belief that they are responsible for their own learning. (p. 489)

Essentially Bergman, Overmyer, and Wilie’s (2013) notion that the real key to the success of the flipped classroom comes from the students’ owning their education is found to be supported by other research, which speaks to the effectiveness of student-centered learning and motivation in the flipped classroom (Abeyseker & Dawson, 2015; Muir, 2016).

**Enhanced communication with students.** As a result of the fact that most of what could be considered the core content is managed by the student in their home environment, the classroom teacher is allowed more in-class time to communicate individually with students (Bergmann & Sams, 2014). Freeing the classroom space of a one-sided delivery of information, as commonly seen in direct instruction, allows for conversation between educator and student (Bergmann & Sams, 2014). Caicco (2016) also found that in addition to the richer communication, flipped classes allow for more individualized instruction, as the teachers had more time to meet the needs of their students. As a result, the relationship between student and teacher enhances the student-based learning environment, which directly improves student motivation as discussed in the section prior (Muir, 2016).

**Testing.** As the flipped classroom is a strategy that is relatively new in education, the impact this style of instruction has on test scores is not well documented on a national level (Caicco 2016). Because the idea is still novel in educational research, the only results reported that can be analyzed come from individual schools themselves (Caicco, 2016). Caicco (2016) also found that when analyzing five different case studies each institution recorded higher scores on their respective state or national exams. One of the instances Caicco (2016) studied includes a
high school in Minnesota where Fulton (2013) reported the positive change that came from engaging students through a flipped classroom, as after five years with the new implemented curriculum the number of students who passed the state mathematics test rose from 29.6% to 73.8% - an increase of 44.2%. In Maryland, Roshan and Roshan (2012) found that the number of AP Calculus students that scored a 4 or 5 on the national test rose from 58% to 78% after the switch was made to a flipped classroom. Caicco (2016) mentions three additional case studies, each of which noted an increase in testing scores for their students. While the impact flipped learning has on students is not yet known on a national scale, the cases discussed by Caicco (2016) shine positive light on the effect this technique has on test scores.

**Criticism.** While the flipped classroom was designed for all students when it comes to classroom instruction, there are some drawbacks to implementing that style of teaching (Caicco, 2016). With the students working at their own pace, and mostly in their own time, Srivastava (2014) noted that in some cases the students may find difficulty in communicating with teachers if they have specific content questions when working from home. The heavy influence of technology may also limit the accessibility for students who might fall into a lower socioeconomic level than other students (Caicco, 2016). Caicco (2016) explains that some students might not have the “the latest gadgets, and so it takes a little bit more planning” to work the flipped aspect into those students’ schooling experience (p. 34). Also, for schools where personal technological devices are not distributed to all students, sourcing out laptops or tablets on a personal basis could be difficult. Most flipped classes also require at-home internet service to work on the content, another factor possibly deterred by varying socioeconomic status of students (Caicco, 2016). Through Caicco’s (2016) interviews and research, the workload on the educator has also been found to be more burdensome than standard direct instruction. Often, the
technological preparation can be unsustainable throughout the course of the school year due to the intricate multimedia aspects (Caicco, 2016).

Srivastava (2014) also notes that, like every form of educational strategy, the method of instruction will not work for every student, as all students have different motivational and organizational skills. With flipped classrooms being heavily based on the constructionist view of education and many students finding self-guided learning to be problematic due to a lack of organizational skills and perseverance of task, there will likely be a percentage of students who do not succeed under this form of teaching (NCTM, 2005; Srivastava, 2014). Considering Gardner’s Theory of Multiple Intelligences, in which different students learn in a variety of ways, the flipped classroom, due to its limited way of delivery during the at-home component, can be problematic for some students (Davis, Christodoulou, Seider, & Gardner, 2011). Subsequently, some students may have trouble learning information when it is presented through a computer. Srivastava (2014) does explain that in most cases this independent method of pacing and learning for the students is still preferable for most students in comparison to the possibility of lecture-based learning.

It should be noted that there was very little literature on the required organization and determination skills needed by the students to succeed in a flipped classroom. Actions taken by educators when students do not participate and simply refuse to work on the content were also not discussed. This perhaps is a result of the novelty of the technique or speaks to the limited research done in this field.
Research Methodology - Description of Study

Introduction

This research was designed to compare two teaching methodologies, direct instruction and the flipped classroom, to assess how each strategy impacted student behavior in the mathematics classroom and performance on assessments. To truly get a rich, encompassing picture of how the students are influenced by the style of instruction, two methods of data collection were integrated into the study. While testing is generally the significant denominator in student performance, this assessment lacks in evaluating student engagement and interactions with the teacher and classmates, so other means of studying these classroom qualities had to be integrated in the research in order to best explore how teaching mathematics matters to the success of the students in testing. Performance on assessments should ultimately be considered due to the importance of test scores on a national level (Gawthrop, 2014).

Research Methodologies

The research was conducted using quantitative and qualitative methodologies. As discussed in the literature review, test scores have been correlated to instructional strategies in educational research for many decades (Schug, 2003). With flipped classroom strategies only recently gaining mainstream attention, the lack of national research on the impact of flipped learning classrooms on test results called for a comparative study to evaluate how this method of indirect instruction affected student scores in high school math classrooms (Caicco 2016).

While testing is, on the national level, perceived to be the tell-all indication of effectiveness of instruction and assessing student knowledge, it does not always fully reflect students’ academic ability as other factors, like testing anxiety, can disrupt results (Gawthrop, 2014). To address this concern, class observations were conducted to ascertain how the factors,
such as student engagement, found in each class might differ. By observing elements such as student engagement, student-teacher interactions, and student to student interactions, a clearer understanding of how class activities impact how much and what kind of learning occurs in each classroom can be deduced. Essentially, through comparing the student experience within the classroom to subsequent test scores, the researcher can begin to conclude the impact instruction might have on learning. Much like the ideas presented by Rosenshine (2008) and explored in the literature review, much of the criticism of direct instruction comes from the lack of student-centered learning and subsequent engagement. By analyzing data collected from class observations and evaluation of student performance on written test items, an understanding of how instructional strategy impacts student test scores can be explored.

Data Collection

Class Observations. Two classes were observed for 8 one-hour class periods over a one-month time period. In the direct instruction classroom, this encompassed two units of instruction: circles and angles of circles. Because the flipped classroom featured students working at their own pace, lines of distinction of where the students were in terms of content were not as concrete, but the researcher ensured the content being covered was indeed the same between the two classes through correspondence with the classroom teachers.

Throughout these observations, specific procedures were used to document elements of the classroom described by researchers as being typical characteristics of each type of instruction, specifically, student engagement, types of student interactions with others, and attitude toward the subject matter as evidenced by student behavior. The observation instrument can be found in Appendix D. There are four sections to this observation instrument. The first page assessed the physical environment of the classroom, which included the arrangement of the
classroom, in order to record the teacher’s locations and roles in the classroom throughout a class period. While these instruments had rough guidelines, they allowed the researcher to record observed attributes that felt impactful to the research findings. For example, while the first page listed various elements of the physical aspects of the classroom, the flexibility of the tool allowed the researcher to make note of any pertinent physical environmental differences that might have impacted learning not originally intended to be observed. The second page focused on student engagement and motivation during the lesson, including reactions from the students, questions asked by the students, and frequency of completion of tasks. The third page looked at the teachers’ behavior and characteristics throughout the lessons, including teacher location and activity frequency. The final page functioned mainly as a record for general teaching observations, including teacher interactions with students, examples of differentiation, and implementations for students who need help. Furthermore, the tool allowed for the researcher to examine multiple aspects of class instruction in the most systematic, non-biased manner as possible.

**Researcher Presence.** Initial non-research-based observations allowed for the researcher to become familiar with both classes. Once research began, the researcher’s presence was explained to students by both teachers to be teacher-focused. Throughout the observations the researcher would generally stay in the back of both classrooms, moving around the rooms every ten minutes to gauge activity and engagement. Very little contact came between the students and researcher, with only occasional questions being asked to students in both classes discussing math content and learning. Since the researcher was observing normal routines in the class and the students would experience the same instruction if the researcher was not in the class, concern of the impact of the study on the teacher or the students is minimal.
Written Mathematical Tasks. A 5-question exam was created for and completed by the two classes. The items included in this test are in Appendix E. The test itself was created to not only evaluate content knowledge, but also to determine if certain groups performed better on different styles of questions. Therefore, the test included a variety of styles of questions, from simple assessments that required a recalling of factual knowledge, to more analytical questions that required a deeper understanding of the content and how mathematical ideas worked together conceptually. Five questions were chosen as they sufficed to show the varying thinking skills and benefited the data analysis as a result of the limited research time. The number of questions, as well as the questions themselves, were chosen to reflect types of questions commonly seen in both class assessments. This was confirmed by comparing and designing the questions around planned in-class assessments from both classes. The teachers who participated in the study were asked to approve the test, both of whom did. These questions were included in regularly scheduled testing periods in both classes. Since the testing procedures were part of the normal class routine, the students were not aware that these questions would be evaluated as part of the study.

Scoring the test was ultimately structured to make each question worth the same amount, with point distribution modelling how both teachers would have graded exams. This was also done in order to help define strengths and weaknesses in both classes in relation to the thinking skill required to answer the questions. Subsequently, each question on the test was worth two points. For the first question, which tested the students’ recall of information, one point was given if a student correctly answered one of the recalled values, two points were given if both values were correct. For the second question, one point was given if the student correctly identified if the statement was correct, and an additional point was given if the explanation of
reasoning was given and made mathematical sense, which assessed students’ understanding and applying concepts. For questions three through five, in which each challenged different conceptual understandings (including analysis and evaluation), one point was given if logical work was shown to get to an answer, and an additional point was given if the correct answer was found. While the questions in the direct instruction class were the same as in the flipped class, they were interspersed throughout a unit test at the request of the classroom teacher. Questions on the test were standalone though, like the flipped classroom, as there were no added hints or clues due to other questions being included in the unit test.

Due to a miscommunication between the researcher and one of the classroom teachers, there was misdirection in the explanation of question four when presenting the students with these questions. This garnered mixed results from the students in their answering of the question. To properly compare the results, this question was removed when the resulting data was analyzed.

**Participants**

**Recruitment Procedures.** Initial groundwork for this research began with the idea that comparisons would be made between two secondary math classrooms, with one working with a direct instruction model and another featuring some form of indirect instruction (the specific form of the indirect strategy was not a qualifier). To narrow down the search for educators, two criteria were established:

1. The classroom teacher was currently teaching high school geometry.
2. The classroom teacher had used the instructional method for the base of their instruction (either direct instruction or indirect instruction) in the past.
The subject of geometry was chosen as it was the most familiar to the researcher and offered a balanced blend of conceptual and procedural knowledge, making it appropriate for direct and indirect instruction styles. It was also important that the qualifying teachers had used their respective method of instruction in years prior to this research. While first-time implementers of any strategy could find success in the classroom, the researcher searched for classes where problems associated with teacher practices or misconceptions had already been resolved in years past. Due to the novelty of the flipped classroom, it was important that the teacher had utilized the method of instruction for at least one school year. This qualification, therefore, was extended to the direct instruction classroom as well to maintain consistency.

In finding appropriate participants, the researcher forwent any specific methods of recruitment, like snowball recruitment, in which potential participants recommend other participants, or media recruitment, where advertisements were utilized and purchased (Eide, 2008). Instead, convenience sampling was used, which employed the researcher’s familiarity and comfort with local geometry teachers due to the amount of field work previously completed. In working with various educators in the past, the relationships created allowed for a network of teachers open to the idea of research being done in their classrooms. A cursory survey was conducted of all possible classes through an internet search, but many were not used because of inaccessibility or other characteristics such small or excessively large classes or not teaching geometry. Due to the resulting small number of appropriate, possible participants, the other recruitment styles were not appropriate for this research.

After the necessary criteria was established and applied to the larger pool of possible participants, potential participants were contacted to verify interest in inclusion in the study. From this contact, the participant pooling began with five educators in Southeastern Louisiana.
In response to the comparative nature of the research, the researcher contrasted all possible participants in order to find two classrooms that matched the needed criteria. Due to the prevalence of direct instruction in schools, the frequency of indirect-based math classrooms was low when reviewing the recruited teachers. Subsequently, only one indirect classroom was available for inclusion in this study, resulting in that school forming the basis for the selection of the class using direct instruction. The remaining pool of direct instruction classes were narrowed down to those that had an environment, culture, and resources that most closely matched the class using indirect instruction. Finally, one class was picked that used direct instruction and most closely matched the demographics and culture of the class using indirect instruction.

**Description of the Participants.** After two classes were selected, the teachers were contacted to verify their interest in participating in the study. Upon review and signing of the informed consent forms, preparations began to collect the data. Pseudonyms were given to retain privacy of the participants. An initial observation was completed in both classes for the researcher to become familiar with the learning environments. This also allowed the researcher to schedule additional observations and review assessments to begin constructing the written exam. Pseudonyms were given to retain privacy of the participating teachers and only those characteristics relative to the study will be discussed.

**Classroom F (The Flipped Classroom).** Carl Smith has taught for over forty years in various levels of education. He teaches geometry at a private, co-educational school in Southeastern Louisiana. The school offers grades Pre-Kindergarten to 12th, with the total student body estimated at around 740 students. 8th through 12th grade students make up approximately 37% of the student population, or around 270 students. Hence, the overall school culture is much more diversified when it comes to student age in comparison to the other classroom. The average
class size is 18 students, while the student to teacher ratio within the school is 9:1. The school’s cultural breakdown was shown to be of majority white students, with 20% of the population being made up by students of color. Each student at the school is required to use a school-chosen personal laptop as an aid in the classroom. Mr. Smith’s class is casual as there are no assigned seats or rows of desks. Instead the students choose their own seats (the seats themselves being made up of a variety of styles including standard chairs and rolling options) around 4 tables centered in the classroom. The class of student observed for the research was a general education geometry class of 18 sophomore students, six of whom were students of color.

Generally, students would enter the classroom and begin working independently. During this time the teacher would electronically record attendance. On occasion, the teacher would have to get the class started and motivated to work, but that period would not last more than a few minutes. Throughout the class time students would work on their laptops completing lessons, working through assessments, or engage in a demonstration by the teacher. When students had questions, they would usually ask the students around them first, then, if needed, resort to asking the teacher for assistance. If there were certain areas where many of the students had difficulties, the instructor would teach on a class-wide level, normally in the front of the classroom. Work would continue until the class ended, with students simply leaving on their own, without any bell or notice from the teacher. The students were required to keep their own time, which was a school-mandated rule. Students also had the freedom to work on the lessons at their own pace for homework. The homework component was mainly where most of the standard-based content delivery would occur, with students completing exercises and watching interactive videos at their own time using the previously mentioned laptops, which were able to be brought home.
Classroom D (The Direct Instruction Method). Jane Miller has been a high school teacher for 12 years. She actively teaches geometry, advanced math, and Calculus 1 at a private, Catholic, co-educational high school in Southeastern Louisiana. The school, which offers grades 8th through 12th, consists of 320 students. Unlike the other school, which included all grades, the culture is more mature. The student body is a majority white, with 9% of its population being made up of students of color. The average class size is around 21 students, with the student to teacher ratio being 15:1 within the school. The students at the school frequently use personal iPad tablets, as mandated by the school, in their classroom experiences. In Ms. Miller’s classroom the students are arranged in rows of desks, each facing towards the whiteboards and smartboard along the front wall. The environment of the classroom is structured, with of the instruction being teacher-led. The class observed for research purposes was a non-honors geometry class made up of 24 sophomore students, five of whom were students of color.

The class periods usually began with students entering the room and waiting for the teacher to begin the lesson. After a few minutes, Ms. Miller would take roll on her computer and move to the front of the class to begin the lesson. On occasion the lesson would begin with a homework/classwork check, but these were limited as homework was normally delivered electronically. Once the teacher began the lesson, the students would consistently take notes, either on their iPads or in notebooks. The delivery of instruction would generally be through lecture, but the teacher would intersperse example questions for individual practice throughout the lesson. Class would normally end with a set of activities called classwork from the textbook, which gave students more practice with exemplar problems. Students would leave classes when signaled by a school-wide bell system.
**Content.** During the time of observations, both classes were introducing the in-depth topic of circles. Throughout the course of the research, the concepts of radius, diameter, circumference, and area were covered. These lessons also delved into angles of circles, specifically inscribed angles, along with arcs, chords, secants, and tangents. In the case of Ms. Miller’s direct instruction class, the observations lasted two full units of teaching. Content was ultimately not the focus of this research, instead the construction of the study could have been used in any math classroom with only few modifications, specifically the questions asked on the assessment.

**Review of the Ethics.** All facets of ethical review were completed under the guidelines of the Internal Review Board (IRB) at the University of New Orleans. Participants were never involved in any type of harmful situations during of the research, but the option to opt-out of participating was always made available. Before confirming participation, the selected educators were required to fill out consent forms, which like the IRB approval can be found in appendix C and appendix A respectively. These consent forms gave the teachers a thorough description of what was to be expected when participating and the guidelines of the ethical review.

Throughout the data analysis pseudonyms were given to the teachers and schools/classrooms were given corresponding letter titles to ensure anonymity. All information regarding the data has been kept with the researcher and stored in a locked room. Data will be destroyed after the appropriate time as designated by the University of New Orleans and the IRB.

**Limitations of the Methodologies**

As mentioned before, the research was completed using observations and evaluation of written mathematical tasks. While the test results can give evidence as to how students perform in response to the teaching methods, the use of observations afforded the opportunity for the
experiences encountered by the students of the classrooms to be properly recorded and analyzed, giving a much richer understanding of how the teaching styles might impact student learning. Using these data collection methods, however, does pose challenges and limitations to the study findings.

**Sample Size.** The research was conducted using only two high school classes, resulting in a sample size of under 50 students in total. The classes were also both from private schools. As a result, the qualitative characteristics observed, as well as the types of questions asked on the assessment, can be applied to any math classroom environment. While the sample size was relatively small, the results can still give an insight into the connection between instruction and student performance due to the universality of the methodologies used.

**Time Constraints.** The researcher was only afforded one month to spend in both observed classrooms. While this time was limited, a total of 16 one-hour-long observations were able to be completed, with 8 done in each environment. While generalizations of this study could have benefitted from longitudinal research, the researcher was able to record at least a full unit of material from both classes. This time frame did allow for assessments to be given, and as a result, still produced sufficient data to explore the findings.

**Researcher Biases.** The classes in which the field work was done were not new to the researcher. Relationships with both teachers had already been established in years past. As a result, the researcher fought against bias by basing all conclusions from the qualitative data by only using observable and quantifiable characteristics. The quantitative data is inherently more objective and less susceptible to researcher bias, so the normal procedures to prevent researcher bias were sufficient when collecting and analyzing that data.
Lack of Pretest. As explained in the time constraints section above, the research was done in only a month-long period. In order to schedule adequate observation time and include time to gather the assessment data, the researcher went on a pretest, which resulted in limited information in terms of what the observed students knew before the instruction began. As a result, the assessment questions were designed around content that was covered during the research timeline. Refining questions to the specific content allowed for the results to speak more of the impact of strategy and less on the prior knowledge of students.

Limited Content. The research was only conducted in classrooms that were teaching geometry as it was a comparative study. While the instruments of data collection were designed with this content in mind, they were also designed to universally work in any content setting. While the assessment questions were constructed around geometry concepts, questions testing the same levels of thinking could easily be created for another subject area. This limited content could also have an impact on student attitudes towards learning, as some may find geometry more interesting or less interesting than other subjects like algebra or calculus. Due to this unknown, the impact of actual content being taught in comparison to the impact of the strategy could be blurred.

Presence and Influence of Researcher. While the research did not require invasive changes to the students’ classroom routines, the presence of someone new can cause disruptions in the classroom environment. In order to combat this, initial observations were done without research in mind to gain a general feel of the environment and to normalize the presence in the learning environment. Throughout the observations, the teacher also kept distance from the students as to maintain their standard learning conditions.
As a result of the previously mentioned limitations, and much like the research previously conducted on flipped learning, the data can in no way be perceived and theorized as a telling truth of the national experience for students and educators. Studies such as these enable future researchers to build on these initial findings and can be combined with other research, such as Caicco (2016 or Srivastava (2014), to build a larger understanding of the impact these strategies may have on how and what students learn.

Methods of Data Analysis

Class Observations. Once the observations were completed, the forms were reviewed and organized for analysis. Subsequently, the data found in the forms was divided into two sections: student engagement and teacher activity. These two topics were chosen as they, when combined, synthesized the experiences in the classrooms in respect to the strategy being studied.

Student Engagement. Student engagement averages were found using the observations at ten-minute periods, with the number of both students on and off task being recorded. Notes were made distinguishing which activities were disengaging students at the same time, which resulted in data that highlighted which activity caused the most disruption. Student to student interaction, as well as the frequency of content-based questions asked by the students were also recorded and averaged.

Teacher Activity. Observations of the teachers were recorded in ten-minute increments like the students. The location of the teacher was noted, with percentage of time spent in various location around the classrooms. The researcher also made note of activities being completed by the teacher during the time periods, each of which were recorded. The actions were tallied up and percentages of each activity were found in respect to all the activities completed in the full class period. This, along with the student engagement data, allowed for connections to be found
throughout the results and gave organization to the data, which framed a basic understanding of how the classes were run.

**Written Mathematical Tasks.** The quantitative data analysis was compiled using the scores received on the test given to both classes. For Class F, the assessments were given to the researcher to keep, while in Class D, the researcher was asked to only keep photographed copies of the assessments. With the data in hand, results were separated by correct answer and reasoning. Records were kept of how many students received a point and how many did not. Separating points given for reasoning or work from points given for the correct final answer allowed for an evaluation of conceptual understanding in respect to the given strategy. The averages were found simply by calculating the mean of the points received. While analyzing the data, the researcher broke the scores down by gender to work on smaller sections at a time. The data was recorded on tables, and reflected this, which resulted in possible implications that this research did not initially intend to find.

**Data Analysis and Findings**

**Class Observations**

This research aimed to compare two strategies, direct instruction and the flipped classroom, to assess whether the methods of how mathematics is taught impacts student behavior in lessons and test scores. Observations were completed to form a basis of *how* these strategies are being implemented in the classrooms, and to gauge how the different teaching strategies impacted student engagement and teacher actions. Each class was observed eight times for one-hour periods using a constructed observation tool over a course of one and half months. Below are tables and figures recording the witnessed characteristics of the observed classrooms, broken
down into student engagement and teacher activities, each followed by a synthesis of the findings.

**Student Engagement.** For this research student engagement was defined by the following characteristics:

*On-task Time.* The researcher recorded the number of students actively engaged in the lesson and found averages per class period. Off-task behaviors was also noted. On-task behaviors included taking notes, listening to the instructor, working on problems, asking questions, and discussing math content. This also resulted in the recording of factors in the classroom that caused disengagement for the students. Each of these characteristics were measured in order to describe how and in what way students were engaged or not through the period.

*Questions Asked.* Throughout the observations, the researcher made note of the frequency of questions asked by the students. This was done in order to characterize the direction of conversation between the student and teacher. These results were designed to understand the interactions between student and teacher and the subsequent engagement that follows.

*Student-to-Student Content Discussion.* For every class period the time spent between students discussing math concepts was also recorded. Averages of these times were found through calculating the mean. Due to the differences in the fundamental nature of both methods of instruction, this measure of engagement was recorded to study if the increase of student-to-student interaction would lead to higher test scores.
### Student Engagement Observations for Class F (Mr. Smith’s Flipped Classroom)

<table>
<thead>
<tr>
<th>Class F</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Percent of Students on Task (Ten-minute Intervals)</td>
<td>:10</td>
</tr>
<tr>
<td></td>
<td>89%</td>
</tr>
<tr>
<td></td>
<td>92%</td>
</tr>
<tr>
<td></td>
<td>89%</td>
</tr>
<tr>
<td>Off-task Behaviors Observed</td>
<td>Misusing personal laptop</td>
</tr>
<tr>
<td></td>
<td>Not observed</td>
</tr>
<tr>
<td></td>
<td>Sleeping or head down</td>
</tr>
<tr>
<td></td>
<td>Number of Content Questions Asked by Students</td>
</tr>
<tr>
<td></td>
<td>Student-to-Student Content Discussion (in minutes)</td>
</tr>
</tbody>
</table>

*Table 1.* Student engagement observations for Class F (Mr. Smith’s Flipped Classroom).
<table>
<thead>
<tr>
<th>Off-task Behaviors Observed</th>
<th>Misusing personal tablet</th>
<th>Sleeping or head down</th>
<th>Off-topic discussion</th>
<th>Number of Content Questions Asked by Students</th>
<th>Student-to-Student Content Discussion (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:10 -- 89%</td>
<td>3 students on 6 occasions</td>
<td>3 students on 2 occasions</td>
<td>4 students on 3 occasions</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>2:20 -- 85%</td>
<td>3 students on 3 occasions</td>
<td>2 students on 3 occasions</td>
<td>5 students on 6 occasions</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>3:30 -- 70%</td>
<td>20 -- 83%</td>
<td>Not Observed</td>
<td>2 students on 3 occasions</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>4:40 -- 78%</td>
<td>20 -- 71%</td>
<td>Not Observed</td>
<td>Not Observed</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>5:50 -- 74%</td>
<td>50 -- 79%</td>
<td>Not Observed</td>
<td>Not Observed</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>6:60 -- 82%</td>
<td>60 -- 92%</td>
<td>Not Observed</td>
<td>Not Observed</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Average: 79.67%</td>
<td>Average: 85.50%</td>
<td>Average: 91.00%</td>
<td>Average: 88.00%</td>
<td>Average: 83.00%</td>
<td>Average: 81.33%</td>
</tr>
</tbody>
</table>

### Table 2: Student Engagement Observations for Class D (Ms. Miller’s Direct Instruction Classroom)
<table>
<thead>
<tr>
<th>School</th>
<th>Observed Quality</th>
<th>Overall Average (per lesson)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Percent of Students on Task</td>
<td>85.81%</td>
</tr>
<tr>
<td></td>
<td>Off-task Behaviors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misusing personal laptop</td>
<td>3.25 students on 3.63 occasions ≃ 3 students on 4 occasions</td>
</tr>
<tr>
<td></td>
<td>Sleeping or head down</td>
<td>0.13 students on 0.25 occasions ≃ 0 students on 0 occasions</td>
</tr>
<tr>
<td></td>
<td>Off-topic discussion</td>
<td>3.63 students on 4.25 occasions ≃ 4 students on 4 occasions</td>
</tr>
<tr>
<td></td>
<td>Questions Asked by Students</td>
<td>14.75 ~ 15</td>
</tr>
<tr>
<td></td>
<td>Student-to-Student Content Discussion</td>
<td>44.38 ~ 44 minutes</td>
</tr>
<tr>
<td>D</td>
<td>Percent of Students on Task</td>
<td>82.83%</td>
</tr>
<tr>
<td></td>
<td>Off-task Behaviors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misusing personal laptop</td>
<td>3.50 students on 5.25 occasions ≃ 4 students on 5 occasions</td>
</tr>
<tr>
<td></td>
<td>Sleeping or head down</td>
<td>0.75 students on 1.38 occasions ≃ 1 student on 1 occasion</td>
</tr>
<tr>
<td></td>
<td>Off-topic discussion</td>
<td>3.75 students on 3.75 occasions ≃ 4 students on 4 occasions</td>
</tr>
<tr>
<td></td>
<td>Questions Asked by Students</td>
<td>4.88 ~ 5</td>
</tr>
<tr>
<td></td>
<td>Student-to-Student Content Discussion</td>
<td>15 minutes</td>
</tr>
</tbody>
</table>

Table 3. Student Engagement Averages for Both Classes.

It was clear from observing both classes that the students were engaged throughout each period, with both classes having average student engagement over 82%. The flipped classroom showed a 3% positive difference in overall engagement, which could have been due to the ownership taken by the students when working at their own pace as that characteristic was unnoticed in the direct instruction classroom. The direct classroom, which featured mostly
lecture and sample problems, kept student on task by encouraging note-taking and working through examples throughout the lesson. These results were not unexpected, as even though both teachers vary in instructional strategy, they both successfully use their methods of instruction to keep students engaged.

The frequency of questioning from the students was much higher in the flipped classroom, an average of 15 questions a lesson compared to the direct instruction’s five. This can be explained by the fact that the students in the flipped classroom were mostly engaged in self-directed learning. The direct instruction class did not appear to form a line of communication with the teacher or other students throughout the lessons, as noticed by the number of questions asked and the time spent with other students. The teacher in the direct instruction classroom had control over the communication as a result of the amount of lecture-based instruction. Following the descriptions presented by Caicco (2016) and Srivastava (2014) in the literature review, the student-to-student interactions are a typical characteristic of a flipped learning environment, so this was not a surprising result.

There were similarities in the disengagement occurred for both classes -- the constant integration of technology and off-topic talking between students. In the flipped classroom, all lessons are conducted on personal laptops, which allowed for students to step away from the content material and surf the web instead. In the direct instruction class, every student has an iPad tablet, though not all use them for note-taking. It was observed that these tablets were the main culprit for disengagement in the direct instruction class, as students were able to switch to social media and games throughout the lesson. It was found that on average both classes would expect to see around three to four students disengaged by technology at various times throughout the lesson, with the direct classroom experiencing only a slightly higher frequency of disengaged
occasions (five) compared to the flipped classroom (four). Because Ms. Miller juggled lecturing and classroom management, in comparison to Mr. Smith’s increased use of technology (where management could occur), these results can be understood.

It was also noticed that off-topic discussions were a common reason for disengagement for both classes, with both experiencing on average four students disengaged on four occasions per lesson. Both environments allowed for quick re-engagement through teacher presence, with the flipped classroom being monitored electronically and the direct instruction classroom featuring proximity. The flipped classroom did not show any significant signs of students consistently sleeping in class, but the direct classroom did, with an average of one student on one occasion during each class period. Overall it was interesting to note that although technology was implemented into the class environments as helpful tools, students have turned to these aids as methods of disengagement equal to that of off-topic discussions.

One of the most significant findings came in the analysis of student interaction with one another while discussing math concepts. In the flipped classroom, the discourse present is a class-wide experience, as students spend, on average, over 44 minutes a lesson engaged with one another talking about mathematics. In the direct instruction classroom, that number is much less, around 15 minutes, which is likely a direct result of the teacher-led model of the delivery of content. These findings were not surprising, as a fundamental part of the nature of the flipped teaching approach is student interaction, as the classes are designed to be student-led. Ultimately the analysis pulled from the student engagement data followed the expected results following the characteristics and elements of both types of classes discussed in the literature review.

**Teacher Activity.** The activities of the teachers were observed and analyzed by location in the classroom and actions done by the classroom teachers.
**Location Averages.** Firstly, the location of the teacher in each classroom was recorded to recognize how the classrooms were run and is shown by the diagrams of the class layouts below.

![Diagram of classroom layout with shaded areas indicating teacher's location.](image)

*Figure 1. Average Location of Mr. Smith in Class F (The Flipped Classroom).*

*Figure 1.* In the figure above, the shaded area in yellow represents where the teacher was located for the percent of the time designated on the figure. While in this area of the class, the teacher lectured to the class or presented information using technology or white board presentations. While in the green area, the teacher was moving throughout the classrooms, often monitoring students work or answering questions. For over half of the teacher’s time they were
in the orange section, which allowed for them to electronically monitor student work and also answer individualized questions.

*Figure 2. Average Location of Ms. Miller in Class D (The Direct Classroom).*

*Figure 2.* In the figure above, while in the yellow area the teacher was usually recorded delivering content through lecture, which was 45% of the time. The teacher was also noted as answering questions from this area of the classroom. While in the green areas, the teacher was consistently moving around the students, which allowed for the teacher monitor student work and manage the students to stay on task. While moving the teacher also answered questions from individual students. Very rarely was the teacher in the back of the room, but if so, the time was spent checking student work or answering questions.

*Activity Breakdown.* The teachers’ actions in the classroom were recorded and are listed in tables 4 and 5. While analyzing data, averages of the activities were found are graphed in figures 3 and 4.
<table>
<thead>
<tr>
<th>Class F</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Activities (Ten-minute Intervals)</td>
<td>:10 -- L,Q</td>
<td>:10 -- Q,S,T</td>
<td>:10 -- Q,S,T</td>
<td>:10 -- Q,S</td>
<td>:10 -- Q,S</td>
<td>:10 -- Q,S</td>
<td>:10 -- Q,S</td>
<td>:10 -- S</td>
</tr>
<tr>
<td></td>
<td>:30 -- L,Q,S</td>
<td>:30 -- Q,S</td>
<td>:30 -- Q,S,T</td>
<td>:30 -- Q,S,T</td>
<td>:30 -- Q,S,T</td>
<td>:30 -- S,T</td>
<td>:30 -- Q,S</td>
<td>:30 -- Q,S</td>
</tr>
<tr>
<td></td>
<td>:40 -- L,Q</td>
<td>:40 -- Q,S</td>
<td>:40 -- S</td>
<td>:40 -- Q,S,T</td>
<td>:40 -- Q,S,T</td>
<td>:40 -- Q</td>
<td>:40 -- S</td>
<td>:40 -- S, T</td>
</tr>
<tr>
<td></td>
<td>:50 -- Q</td>
<td>:50 -- Q,S</td>
<td>:50 -- Q,T</td>
<td>:50 -- Q,S,T</td>
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<td>:60 -- S</td>
<td>:60 -- Q,S,T</td>
</tr>
<tr>
<td>Activity Codes</td>
<td>L -- Lecturing</td>
<td>Q -- Answering Questions</td>
<td>S -- Monitoring Student Work</td>
<td>T -- Using Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 4. Teacher Activity Breakdown for Class F (The Flipped Classroom).*

<table>
<thead>
<tr>
<th>Class D</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Activities (Ten-minute Intervals)</td>
<td>:10 -- L,Q</td>
<td>:10 -- L</td>
<td>:10 -- L</td>
<td>:10 -- Q,S</td>
<td>:10 -- L</td>
<td>:10 -- L,Q</td>
<td>:10 -- Q,S</td>
<td>:10 -- Q,S</td>
</tr>
<tr>
<td></td>
<td>:20 -- Q,S</td>
<td>:20 -- L</td>
<td>:20 -- L,Q</td>
<td>:20 -- L,Q,S</td>
<td>:20 -- L,S</td>
<td>:20 -- L,Q,S</td>
<td>:20 -- L,Q,S</td>
<td>:20 -- L</td>
</tr>
<tr>
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<td>:30 -- L,Q,S</td>
<td>:30 -- L</td>
<td>:30 -- L,S</td>
<td>:30 -- Q,S</td>
<td>:30 -- Q,S</td>
<td>:30 -- L,S</td>
<td>:30 -- Q,S</td>
<td>:30 -- Q,S</td>
</tr>
<tr>
<td></td>
<td>:40 -- L,S</td>
<td>:40 -- L,Q</td>
<td>:40 -- Q,S</td>
<td>:40 -- L,Q,S</td>
<td>:40 -- L</td>
<td>:40 -- L,Q,S</td>
<td>:40 -- L,Q,S</td>
<td>:40 -- L,Q,S</td>
</tr>
<tr>
<td></td>
<td>:50 -- S</td>
<td>:50 -- S</td>
<td>:50 -- L,Q,S</td>
<td>:50 -- L,Q</td>
<td>:50 -- L,Q,S</td>
<td>:50 -- Q,S</td>
<td>:50 -- Q,S</td>
<td>:50 -- Q,S</td>
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<tr>
<td></td>
<td>:60 -- L,S</td>
<td>:60 -- S</td>
<td>:60 -- L,S</td>
<td>:60 -- Q,S</td>
<td>:60 -- Q,S</td>
<td>:60 -- L,S</td>
<td>:60 -- L,S</td>
<td>:60 -- L,Q,S</td>
</tr>
<tr>
<td>Activity Codes</td>
<td>L -- Lecturing</td>
<td>Q -- Answering Questions</td>
<td>S -- Monitoring Student Work</td>
<td>T -- Using Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 5. Teacher Activity Breakdown for Class D (The Direct Instruction Classroom).*
Figure 3. Teacher Activity Percentages for Class F (Flipped Classroom).

Figure 3. The graph was created to represent the averages of the teacher’s activity in the flipped classroom using the data in Table 4. The percentages were calculated by tallying each individual activity in relationship to the sum of all activities. In the flipped classroom, the teacher was shown to spend the most time monitoring student work, which can be seen in the green section. The yellow area is only slightly smaller and represents the time spent answering questions. The dark orange section was found to be less than a quarter of the time spent in the class and represents the teacher using technology. The smallest section, the light orange, signifies lecture.
**Figure 4.** Teacher Activity Averages for Class D (Direct Instruction Classroom).

**Figure 4.** The percentages were found using the same method in Figure 3, but with the data of Table 5. This chart only represents three activities, as Ms. Miller did not show any use of technology in her instruction. The most frequent activity was found to be monitoring student work, which is represented by the green section. Exactly 33% of the time was spent lecturing, which can be seen in the light orange section. The teacher also spent over a quarter of the time answering student questions, which can be observed in the yellow section.

**Findings.** This data provides an overview of the teacher actions and locations in both classrooms throughout the class instruction. It was found that in the flipped classroom Mr. Smith took on more of a role of a facilitator, with over 50% of his time being spent at his own desk. This time was generally used to electronically monitor student work using the online software provided in the flipped learning experience, answer student questions, or deliver content through
technological means. It was found that Mr. Smith spent up to 77.45% of his time checking his students’ progress along with answering questions. These activities were recorded during the 93% of time spent in the classroom where Mr. Smith was either moving around the students or in the back of the room by his desk. The additional 7% of time in the classroom was spent in the front of the room and was made up of very limited lecturing and a portion of the time spent using technology.

It was also found that both teachers allocated nearly 40% of their in-class activity to monitoring student work. This monitoring most commonly occurred while the teacher moved throughout the classroom, hence a correlation can be seen in both classes between time spent mingling with the students and surveillance of their progress (around 40% for each). In the direct instruction classroom, Ms. Miller spent exactly 33% of the time lecturing to her students, which is over ten times the amount spent lecturing in the flipped classroom. It was also recorded that Ms. Miller did not use any technology throughout the time observed in her respective class, which was very different from the integrated technology in the flipped classroom, where close to 20% of Mr. Smith’s activity was spent utilizing some sort of technology. It was also found that Mr. Smith spent 7% more time that Ms. Miller answering student questions, which considering the results of student engagement, is due to the students in the flipped classroom being asked more questions on average. Much like the results of the student engagement data, these findings are not surprising and only further fortify the qualities of the strategies as expressed in the literature review.

**Conclusion.** In order to get a full picture of how both strategies are truly operated in the classroom, the qualitative observations were implemented to measure student engagement and teacher activities. It was found that while engagement was well over 80% for both classes, how
students were engaged was a different picture. In Class F students were engaged by working with one another (on average of 44 minutes a lesson), asking questions (around 15 minutes a period), and embarking on conceptual understandings of mathematics through their own agency (by working on the content throughout the entire 60-minute period). In Class D the teacher spent exactly 33% of the time lecturing in a one-way conversation, with close to 50% of time spent in the front of the classroom. Students in Class D only asked an average of 5 question a day and only spent 15 minutes talking with one another about math – the rest of their time was spent taking notes from the board. Both strategies clearly utilize the time spent in the classroom in different ways. While the qualitative data gave a detailed look into how the classrooms are run, quantitative data must be analyzed to give answers as to how various methods of instructions could lead to different levels of student performance on assessments.

**Written Mathematical Tasks**

Testing, as shown in the literature review, is ultimately the standard for assessing student learning today. This was considered when developing a method for quantitatively assessing student learning. As a result, in order to analyze concrete results and work towards a definitive answer as to if how mathematics is taught matters in regards student success, students were given assessments featuring various levels of questions. The findings are mapped out in the tables below, each with summaries following:
<table>
<thead>
<tr>
<th>Question &amp; Qualification</th>
<th>Questioning Level</th>
<th>Male</th>
<th>Female</th>
<th>Percent of Students Who Received Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1a - correct answer</td>
<td>Remembering: Defining &amp; Finding</td>
<td>13</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>#1b - correct answer</td>
<td>Remembering: Defining &amp; Finding</td>
<td>13</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>#2 - correct answer</td>
<td>Understanding &amp; Applying: Interpreting &amp; Articulating</td>
<td>8</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>#2 - logical reasoning</td>
<td>Understanding &amp; Applying: Interpreting &amp; Articulating</td>
<td>8</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>#3 - correct answer</td>
<td>Analyzing: Integrating</td>
<td>6</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>#3 - supportive work</td>
<td>Analyzing: Integrating</td>
<td>6</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>#5 - correct answer</td>
<td>Evaluating: Detecting &amp; Validating</td>
<td>4</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>#5 - supportive work</td>
<td>Evaluating: Detecting &amp; Validating</td>
<td>1</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6. Question-based Results for Class F (Flipped Classroom)

<table>
<thead>
<tr>
<th>Raw Score (8 Possible Points)</th>
<th>Average Score for Male Students</th>
<th>Average Score for Female Students</th>
<th>Average Scores for Whole Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score (8 Possible Points)</td>
<td>4.21</td>
<td>3.43</td>
<td>3.82</td>
</tr>
<tr>
<td>Percent</td>
<td>52.68%</td>
<td>42.85%</td>
<td>47.77%</td>
</tr>
</tbody>
</table>

Table 7. Assessment Averages for Class F (Flipped Classroom)
<table>
<thead>
<tr>
<th>Question &amp; Point Qualification</th>
<th>Questioning Level</th>
<th>Male</th>
<th>Female</th>
<th>Percent of Students Who Received Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1a - correct answer</td>
<td>Remembering: Defining &amp; Finding</td>
<td>8</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>#1b - correct answer</td>
<td>Remembering: Defining &amp; Finding</td>
<td>3</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>#2 - correct answer</td>
<td>Understanding &amp; Applying: Interpreting &amp; Articulating</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>#2 - logical reasoning</td>
<td></td>
<td>4</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>#3 - correct answer</td>
<td>Analyzing: Integrating</td>
<td>0</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>#3 - supportive work</td>
<td></td>
<td>0</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>#5 - correct answer</td>
<td>Evaluating: Detecting &amp; Validating</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>#5 - supportive work</td>
<td></td>
<td>0</td>
<td>12</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 8. Question-based Results for Class D (Direct Instruction Classroom)*

<table>
<thead>
<tr>
<th></th>
<th>Average Score for Male Students</th>
<th>Average Score for Female Students</th>
<th>Average Scores for Whole Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score (8 Possible Points)</td>
<td>2.00</td>
<td>3.08</td>
<td>2.54</td>
</tr>
<tr>
<td>Percent</td>
<td>25.00%</td>
<td>38.54%</td>
<td>31.77%</td>
</tr>
</tbody>
</table>

*Table 9. Assessment Averages for Class D (Direct Instruction Classroom)*
Levels of Questioning. Because the questions required a variety of skills in answering (ranging from simple remembering up to the more challenging evaluating), the results followed what was expected from the beginning – as a whole, fewer students would receive points for more difficult questions. These varying levels also required the students to do more than just give the right answer. For example, in Question 2, students were asked to determine why the answer they chose made sense. Splitting the questions down into this layered format allowed for a more defined and rich analysis of the data.

Question 1. In both classes, the first question, consisting of two parts, garnered the highest level of student success. In Mr. Smith’s flipped classroom 86% of students received a point for the first part of number one. The average dropped slightly for the second half of the questions, with only 82% of students receiving a point. This result was higher than average of the students in Ms. Miller’s direct instruction classroom, as they scored 75% on part one and 42% on Part 2, a difference of 11% and 40% respectively. The fact that students had less success on the second half was expected, as, although the question only required recalling formulas to find the right answer, the required formula for the second half was more intense as it required the students to recall an additional term.

Question 2. This question required both an understanding of the geometric concept of tangents as well as application in the form of articulating reasoning. Fewer students answered and explained this correctly than for the first question in both classes. In Mr. Smith’s flipped class 61% of students states the correct answer, while only 54% of students were able to give logical responses to why they chose their answer. As in question one, the results for Ms. Miller’s direct instruction class were slightly lower. 58% of her students received a point for the first part, while only 46% received a point for the second half. (3% and 8% less in comparison to Mr.
Smith’s student results) Following the qualitative data analysis on student engagement, it was not surprising that the students who spent less time discussing the content ideas with one another or the teacher had difficulty articulating a response to explain their reasoning. The difference between the scores of both classes was lower for Question 2 in comparison to Question 1.

**Question 3.** This question required students to analyze a real-world word problem and integrate a formula used in class to find the correct answer. One point was given if the correct answer was found and a second point was given if the student successfully backed up their answer with supportive work. As expected, as the question was on a higher level of difficulty, the scores for this question fell once again. In Mr. Smith’s flipped classroom, the points received were even for both halves of the question, with 25% of students receiving two points. Ms. Miller’s direct instruction class also followed suit with an equal distribution of points between halves of the question, with 8% of students receiving both points for question three. The scores from the direct instruction class were 17% lower than those in the flipped classroom. It was found that in both classes every student who stated the correct answer also logically supported their work. Hence, the only students to receive points for this question received two points. The level of thinking required to correctly work through and answer the problem was likely the determining factor in why the points received turned out like this. Not only were scores lower, as the problem was more difficult, but the required understanding to integrate formulas into real-world situations was built off conceptual understanding, which evidently was not as nurtured in Ms. Miller’s direct instruction classroom. These results are not encouraging for either method of instruction though, as over 75% of the students in both classes did not answer correct or justify their response.
**Question 4.** As mentioned in the description of study, the fourth question was removed from any data analysis following a delivery error in one of the classrooms resulting in different answers.

**Question 5.** The final question of the assessment required evaluation on the student’s behalf to detect and deduce elements of a triangle and a circle in order to find a missing value. One point was received if the student answered with the correct value, and an additional point was granted if the student validated their result with logical work. For the first time, Mr. Smith’s flipped classroom results for the first half was higher than the previous question’s average. 36% of students received a point for the correct answer, and 14% of students followed with logical work. Ms. Miller’s scores were once again lower in comparison to Mr. Smith but stayed the same in comparison to the scores of the previous question. On average, 8% of students received a point on for both halves of the question. Once again, more students in the flipped classroom received points in relation to the scores of the direct instruction class. Because this question, like question 3, required a more advanced level of conceptual understanding, it appears the flipped classroom, through its student-to-student engagement, did a better job of preparing students to think on higher levels.

It should be noted that all questions were reviewed by both instructors prior to the delivery of the assessment. All questions were designed to match possible exemplars seen in both classes. Following the generally lower assessment results, future research questions would be planned to more directly match items worked out by the students during their in-class activities.

**Overall Scores.** The overall average score for both classes was under 50%, with Mr. Smith’s flipped classroom receiving a 48% and Ms. Miller’s direct instruction classroom scoring
a 32%. When compared to Ms. Miller’s students, Mr. Smith’s class scored 16% higher on the assessment. In terms of raw points, in which the test was out of 8 points, Mr. Smith’s class scored an average of 3.32 points and Ms. Miller’s class scored an average of 2.54 points. Once again, it can be observed that through assessment scores, the students who experienced the flipped teaching methodology had more success in answering a variety of questions designed from teacher-approved exemplars, each challenging different levels of thinking.

**Gender.** When the organization of the data analysis began, the researcher made the decision to break all the results down by gender to work on smaller sections at a given time. Though this was initially done simply to make the data analysis simpler, through working with the results, some interesting outcomes were brought to light. In Mr. Smith’s flipped classroom, male students scored around 10% higher overall on the assessments in comparison to female students. In Ms. Miller’s direct instruction classroom, the females scored on average around 14% higher than male students. From these results, it would appear that perhaps flipped learning fostered more success for male students, while female students embraced a richer learning experience through direct learning. Ultimately this research was not done with gender in mind, so these results would have to be further explored through more in-depth, specified research.

**Conclusion.** Using the quantitative assessment allowed the researcher to analyze concrete results in terms of student learning achievement for both classes. While the qualitative observations painted a picture of how the classrooms were organized and conducted, the effect these teaching strategies had on student learning could be refined and explored more concretely when measured by a quantitative result. The test gave the researcher the opportunity to organize learning skills by difficulty of question, which showed that for every case the flipped classroom environment resulted in higher scores in every level of thinking when compared to the direct
instruction classroom. The differences in points received ranged from 2% to 41% depending on the question, with the flipped classroom coming ahead in every category. From these results it can be concluded that based on the points received for every question, Mr. Smith’s flipped learning strategy resulted in better student learning when compared to Ms. Miller’s direct instruction strategy.

While the test scores do indicate increased learning, there are some serious concerns about what these scores truly reflect. Firstly, the researcher relied on the classroom teachers to approve the assessment questions. While the educators believed the students could succeed at answering the problems, the items on the test might have not connected to actual problems the students had practice with during the in-class periods of instruction. While the questions were directly modeled from assessments given by both teachers, a transfer of learning would be expected if students had previously done similar problems in class. The relatively low scores for both classes have become a cause for concern for the researcher, as the correct steps were taken to properly design an assessment truthful to what the students would be expected to know.

Following the miscommunication regarding question 4, the wording of the questions and given diagrams have also come under scrutiny. Once again, all questions were directly designed from assessment questions delivered in both classes, but the dip in scores could perhaps have been due to a misunderstanding of what was being asked of the students. While this is unlikely due to the nature of the other questions, the prospect is still possible.

It should be noted that while this data reveals the above results, there are other factors that could have led to the observed outcomes. Diversity in the following characteristics might have caused the results to turn out the way they did: students’ prior knowledge and previous
learning experiences, socioeconomic groups in private schools, and teacher rapport with the classes.

**Implications and Impact**

**Review of Findings**

This study was designed to compare two instructional strategies, direct instruction and the flipped classroom, to uncover if how mathematics in the secondary school environment is taught has an effect on assessment outcomes. Both qualitative and quantitative data was recorded, with observations and assessments used to gather data.

**Qualitative.** The data uncovered that student engagement averages were over 80% in both classes, a relatively high number for both strategies. It was also found that in the flipped environment, students asked the instructor more questions (15 a day compared to 5) and talked with other students about mathematics content on average more than those in the direct instruction class (44 minutes a day compared to 15 minutes). These findings followed expectations as the student-led nature of the flipped classroom generally primes the learning environment for constant discourse and conversation between students, other students, and the teacher. Teacher behaviors were also recorded as part of the qualitative data. It was found that both teachers spend relatively the same amount of classroom time monitoring students’ work, while Mr. Smith spent an additional 7% of his time answering student questions. The most significant difference in teacher activity was found in lecture time/frequency and technology use, both of which the results followed what was expected from the teaching strategy. Ms. Miller’s lectured for 33% of the instructional time, while Mr. Smith only spent 3% of his time lecturing. Technology was not used by Ms. Miller at all, while Mr. Smith’s flipped integration allowed for him to use technology for around 20% of his time. Ultimately, the learning environment of Ms.
Miller’s direct instruction classroom was one made up of organized lecture and note taking, with a strong teacher presence in the form of one-way teacher presentation and constant monitoring of work, while Mr. Smith’s flipped classroom had a relaxed atmosphere, which, through its student-centered approach, consisted of constant math discussion and student-led activity. These results gave the researcher an in-depth look into how the different teaching strategies resulted in vastly different learning environment and student experiences. These observations also confirmed the presence of characteristics outlined in the literature review.

**Quantitative.** While the qualitative data helped explore how the classrooms were run, the quantitative assessment was created to find any connection between the instructional strategies and student learning. The assessment consisted of four questions, each testing various levels of thinking. It was found that for all questions the students in Mr. Smith’s flipped classroom performed better than those in Ms. Miller’s direct instruction class. The percent difference ranged between 2% and 41% depending on the question. On average the total scores for the students in the flipped class were 16% higher than those in the direct instruction setting. As a result, the data showed that although the direct instruction method focuses heavily on lecture and preparation for testing, the flipped classroom students still scored higher on every question in the assessment. The students in the flipped class, as result of the student-led learning environment, were able to succeed more effectively in answering questions that required conceptual understanding and more advanced degrees of mathematical content knowledge. In respect of both classes, the relatively low scores are still cause for concern about how well these concepts are being learned though. In the end, the flipped class students were somewhat better prepared to succeed at the assessment as a result of the teaching methodology used in their classroom.
**Limitations.** In addition to previously discussed concerns about what this study reveals, it should be mentioned that, this study only tested a specific population of students, making generalization from the findings very limited. This research was conducted in strictly private schools, each restricted in student body diversity and generally consisting of students with higher socio-economic backgrounds. The choice of classroom utilizing an indirect approach to teaching, especially flipped teaching, was also limited as the frequency of use of those methodologies is low due in part to novelty and teacher training. The students being observed and assessed also resulted in some restrictions, as pre-tests to determine prior knowledge were not designed and administered and stability of individual attendance was not recorded.

**Implications**

Despite the previously mentioned limitations, this study highlighted some important implications for those concerned with mathematics education. Firstly, gender may play a larger role in how instructional strategies impact learning for students. In reviewing the quantitative data, the researcher noticed differences in scores when dissecting by gender. This initial research was not formed with gender differences in mind, but the assessment results highlight the possibility that different teaching methods maybe more appropriate for, and better received by, different genders. For example, it was found that in the flipped classroom, male students scored 10% higher than female students on the assessment, while in the direct instruction classroom female students scored 14% higher on the assessment in comparison to the male students. In order to accommodate these differences, teachers might want to explore ways to have a variety of strategy opportunities in their classes.

It was also found that the flipped classroom offers alternatives for student engagement and lesson tasks that may be able to be incorporated into direct instruction strategies that might
increase student test performance. Additionally, teachers who use direct instruction should seek ways to use student-to-student interactions during the lesson as an alternative way to engage students. Providing discourse for students to participate in asking more questions was also a characteristic of the flipped classroom that was shown to be lacking in the direct instruction class. Stepping away from the heavy lectures and note taking and allowing students to take control of their education could also lead to better test results, as revealed in the flipped class. While monumental changes may not seem enticing to some direct instruction teacher, tweaking methods of instruction to reflect those of a flipped classroom may conclude with more conceptualized learning in the form of improved assessment scores.

Finally, teachers should carefully consider why, how, and when technology should be used in their classrooms. It was discovered that in terms of classroom management, technology was one of the biggest reasons for student disengagement in both classes, even though both classes incorporated their respective devices as aides for the learning environment. On average both classes would have 3-4 students on 4-5 occasions disengaging from the lesson and learning experience because of present technology in the classroom. In the flipped classroom the presence of technology is noticed everywhere, with the students consistently using their personal laptops to complete lessons and the teacher spending 20% of the instructional time utilizing some form of technology. In the direct instruction classroom, the students have personal iPads to use, but the teacher does not use technology at all. While the teachers’ levels of use differed, both sets of students constantly had access to technological devices. With the amount of disengagement occurring at the hands of technology, perhaps moving to more of balance between screen-time and another personalized method of learning could enhance student engagement.
Grounds for Future Research

Public Schools. Due to the size of the research and time and budget constraints, this study was limited to on private high school classrooms. It would be intriguing to see how these various strategies play out in the public-school environment. Perhaps the direct instruction method would lead to a different set of results, perhaps even higher test results in areas with different school cultures. Other factors could also be changed in future research such as math content covered and student age (school year).

Student Cultural Background. Both schools observed were made up of a majority white student body population. Comparing these strategies in predominately non-white schools could lead to an understanding of how effective teaching methodologies are for an even wider background of students in the classroom.

Other Indirect Strategies. While comparing direct instruction to the flipped classroom garnered insightful results in terms of student learning and test results, other indirect teaching procedures exist, like discovery learning for example. Comparing these to the results found for both the flipped classroom and the direct instruction classroom could shed even more light on how impactful teaching methodologies are on student learning.

Longitudinal Study. Due to the time constraints of this research, the results would have benefitted from a longitudinal study. This would allow for the researcher to observe how instruction impacts learning over a longer period, perhaps a whole year of instruction. This could have given more concrete results as to how teaching strategies impact long-term retention.

In-class Practice versus Test Questions. The low scores on the assessment questions have influenced the researcher to discuss the idea of exploring the connections between what students practice in classes and what they are tested on. The dismal results would support the
thought that there perhaps is a disconnect between the two. Further research in this filed could impact the importance of testing as whole.

**Content Topics.** While the researcher specifically worked with geometry classrooms, further research could be done to compare the same strategies in other mathematics content classrooms, like algebra or advanced math. Widening the data in respect to content could lead to more generalizable results for both methodologies.

**Assessment Wording and Format.** While delivering the assessment during the research, there was a miscommunication between the educators and students about question 4. Future research could be conducted to explore how the wording and formats of assessments could impact scores as students and teachers can have individualized interpretations of what questions are asking.

**Concluding Thoughts**

This research has suggested that there is indeed a direct relationship between the way mathematics is taught and the success students have in learning and performing on assessments. In comparing direct instruction and the flipped classroom approach, the resulting qualitative data analysis cemented the expected classroom qualities of both learning environments and the quantitative data highlighted the improved testing scores by the flipped learning students. While every teacher has an individual way of presenting content information, utilizing principles explored by the flipped teaching technique, many of which grow conceptual understanding of the student being taught, may lead to higher test scores for students and more effective learning overall. This study’s process has also shown that much of the research presented on these issues is highly simplified and classrooms are more complex than they appear to be, which makes it difficult to accurately ascertain what works best for all students.
References


Bergmann, J., Overmyer, J., & Wilie, B. (2013). *The flipped class: What it is and what it is not*. 


Appendix A: IRB Approval

University Committee for the Protection of Human Subjects in Research
University of New Orleans

Campus Correspondence

Principal Investigator: Cynthia Ybos
Co-Investigators: Brian Comeaux
Date: March 10, 2018
Protocol Title: A Comparison of Instructional Strategies: Does how you teach mathematics matter?
IRB#: 31Jan18

The IRB has deemed that the research and procedures are compliant with the University of New Orleans and federal guidelines. The above referenced human subjects protocol has been reviewed and approved using expedited procedures (under 45 CFR 46.110(a) category (4 and 7)). Approval is only valid for one year from the approval date. Any changes to the procedures or protocols must be reviewed and approved by the IRB prior to implementation.

If an adverse, unforeseen event occurs (e.g., physical, social, or emotional harm), you are required to inform the IRB as soon as possible after the event.

I wish you much success with your research project.

Sincerely,

Ann O’Hanlon, Chair
UNO Committee for the Protection of Human Subjects in Research
Appendix B: Letter of Introduction

<Date>

<Teacher name>

As part of a research project I am doing for the University of New Orleans and as part of my degree requirements, I would like to observe your class as you teach a geometry unit. You will not be required to alter any of your procedures nor will any of the students be required to deviate from their normal routine. I will observe your class and make notes regarding your interactions with the students during the lesson. The goal of the study is descriptive only and not aimed at judging the quality of your instruction in any way.

The amount of time required from you will be minimal. I would like to meet with you prior to my observations to discuss what you will be doing and what I can expect to see from your perspective. After observing your class, I would like to meet with you briefly to discuss your perceptions of the lessons. Other opportunities may arise in which we will communicate either in person or by email, but those will be of minimal duration and at your discretion. I will, however, always be available to discuss any concerns or questions you have throughout this research project.

Thank you for considering this proposal,

Sincerely,

Brian Comcaux
Appendix C: Consent to Participate

1. Title of the research study:

A Comparison of Instructional Strategies: Does how you teach mathematics matter?

2. Project Researchers

   Brian Comeaux, undergraduate student
   Under the supervision of
   Dr. Cynthia L. Ybos
   Room 342B
   Bicentennial Education Building
   University of New Orleans
   2000 Lakeshore Dr.
   New Orleans, LA 70148
   (504) 280-5542

3. Purpose of this research:

   This study is designed to compare classrooms that utilize direct or indirect instruction based on student behavior, teacher behavior, and classroom environment. This information will be used to provide insights into the strengths and weaknesses of differing mathematical pedagogies.

4. Procedures for this research:

   You will be asked to participate in at least two interviews covering the topic of instructional strategies over the course of three weeks. The pre-visit and post-visit interviews will be recorded. Other communication will not be recorded although emails may be used and secured during the course of the observations. The researcher will be observing your classroom and recording written data for around five to ten class periods. This information will be used for completion of an undergraduate honors thesis and in all situations, guarantees of strict confidentiality are hereby given to all research participants.
5. Potential risks or discomforts:

There are no foreseen risks to you if you choose to be part of this study. You will not be asked to deviate from your normal routines. Please contact Dr. Ann O’Hanlon (504-280-7386) at the University of New Orleans for answers to questions about this research, your rights as a human subject, and your concerns regarding a research-related injury.

6. Potential benefits to you or others:

There is no direct benefit to you, however, this study will help document the effectiveness of different teaching strategies when teaching mathematics. There is no monetary compensation for participating.

7. Alternative procedures:

This research has no alternative procedures. Any participation is voluntary, and you may, without consequence, withdraw consent and terminate your participation.

8. Protection of Confidentiality:

Confidentiality will be kept as no names will appear on any artifacts and pseudonyms for schools and anyone participating in this study will be used throughout all written reports. Although no data will be collected that has direct information about the participants, security will still be exercised for all data including any audio recording. All data will be stored in a secure location and will be destroyed after the designated holding period. The audio data will be erased electronically, and any transcripts or forms will be shredded.

9. Signatures and consent to participate:

Federal and university regulations require that we obtain signed consent for participation in research projects that involve human subjects. After the purpose, procedures, benefits, and risks have been explained to you, please sign the statement below to indicate your consent.
I have been fully informed of the procedure described above along with its benefits and risks and hereby give my permission to participate in this study.

Signature of Subject ___________________________ Name of Subject (print) ___________________________ Date ___________________________

Signature of Person ___________________________ Name of Person (print) ___________________________ Date ___________________________

Signature of Person Obtaining Consent ___________________________ Name of Person Obtaining Consent (print) ___________________________ Date ___________________________
Appendix D: Observation Instrument

Observation Instrument

Date:
Location
Lesson topic
Time the lesson began:
Time the lesson ended:

Drawing of the physical arrangement of the classroom:

Notes on the physical aspects of the class (environmental differences that might impact learning such as students' work featured in the class, physical arrangement of student desks, access to educational resources such as technology, general lighting and ambiance, and other observed attributes):
## Student Engagement

Watch the students for at least two minutes at ten-minute intervals.

Total number of students present: ________

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of students engaged in the lesson</th>
<th>Number of students not engaged in the lesson</th>
<th>Description of student behavior (what are the students doing and their reactions to the lesson)</th>
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Student activity code:

- Asking teacher question Q
- Engaged in assigned task T
- Talking to other students S
- Sleeping/head down on desk    S
- Writing notes/completing written tasks  W
- engaged in group work  G

Student behaviors during instruction including physical reactions to the lessons, level of engagement, participation, number of questions asked during the lesson, completion of tasks, and note-taking.
Teacher Behavior

Watch the teacher for at least two minutes at ten-minute intervals

<table>
<thead>
<tr>
<th>Time</th>
<th>Location in class</th>
<th>Description of teacher behavior (what is the teacher doing and interactions with the students)</th>
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Teacher activity code:

Lecturing: L
Using technology: T
Answering student questions: Q
Monitoring student work: S

Teacher behaviors during instruction including questioning the students, effectiveness of the presentation, attentiveness to student behaviors, ability to provide a context for the knowledge being learned, and professional disposition.
General Teaching Observations

4 – Very Evident    3 – Evident    2 – Somewhat Evident    1 – Not Observed

• know their pupils well, know why pupils make mistakes, and be able to make judgements about
next steps or interventions

• share learning intentions with pupils and use them to mark work or give feedback or rewards ___

• build in review time for themselves and their pupils

• encourage pupils to take responsibility for their learning by providing opportunities for pupils to
describe their response to learning intentions or targets, the strategies they use and the judgements
they make in relation to their progress

• give pupils examples of a variety of skills, attitudes, standards and qualities to aim for ___

• analyses pupils’ performance in tests and use the information for future learning plans feel
confident and secure in classroom practice

• differentiated classroom groups ___

• build-in review time and flexibility ___

• notes of pupils who need additional or consolidation work ___

• time for guided group sessions for explicit formative assessment opportunities ___

Notes and evidence of teaching strategy (direct or indirect) used in classroom:
Appendix E: Designed Assessment

Name

Show all work for credit. Problems with no work shown will receive no credit.

[1] If the radius of a circle is 13.1 km what is its diameter? Circumference?

[2] Determine whether AB is tangent to the circle. Explain your reasoning.

[3] A bicycle on flat, dry ground has wheels with a radius of 40 cm. How far will the bicycle move if the wheels are turned through a 270° angle (find the length of the arc).

[4] If the ∠BDC = 35° and the measure of arc AB = 100° and the measure of arc CD = 100°, find ∠1.

[5] Find the value of x. Assume that segments that appear to be tangent are tangent.