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PBL vs. DI: Which Increases Student Achievement and Attitude?

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Abstract

This study investigated the effects of problem solving-based instruction versus lecture-based direct instruction on student academic achievement and attitude. Evidence of student achievement and attitude was collected through a quasi-experimental quantitative methodology. Two classes were used, one as an experimental group being taught with Problem-Based Learning (PBL) and one as a control group being taught with Direct-Instruction (DI). The length of instruction was a two-week unit on basic triangle properties in Geometry. A pre-test and post-test was given to the participants followed with a student attitude questionnaire survey. The data analysis included a t-test with the pre-test and post-test data to determine the significance of learning achievement and a chi-square analysis with the survey data to determine the significance of student attitude towards a particular instructional method. The researcher concluded that a significant gain in student achievement and attitude did occur with the PBL class.

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CHAPTER ONE

INTRODUCTION AND PROBLEM STATEMENT

While in college pursuing an undergraduate degree, the researcher had the opportunity of working at Sylvan Learning Center. Much emphasis was placed on the approach to research-based best practices, using manipulatives, and a three to one student to teacher ratio. The center's mathematics instruction focused on problem solving skills. This would help improve the student's mathematical thinking. The researcher's current instructional practices in Geometry involve students constructing their knowledge from the investigations, explorations, cooperative learning activities, and hands-on work with geometric tools and manipulatives. In addition, students were exposed to technology in the classroom through the use of Geometer's Sketchpad. Furthermore, the researcher believes that structured, well thought out activities lead to student success. Unfortunately, the majority of instruction that occurs in classrooms is lecture-based instruction. This was the main drive to conduct the type of research that will be explained in the following research proposal. The researcher would like to know which type of instruction truly benefits students.

This investigational quantitative experiment explored the effects of problem solving-based instruction versus lecture-based direct instruction on student academic achievement and attitude. Evidence of student achievement and attitude was collected through an experimental quantitative methodology. Two Geometry classes were used, one as an experimental group being taught with PBL and one as a control group being taught with DI. The length of instruction was a two week unit on basic triangle properties in Geometry. A pre-test and post-test was given to the participants followed with a student attitude questionnaire survey. The data analysis included a t-test and ANCOVA as needed on the pre-test and post-test data to determine significance in

learning achievement and a chi-square analysis with the survey data to determine significance in student attitude toward a particular instructional method.

If more research supported problem-based learning, more teachers would be willing to convert from lecture-based to problem-based instruction. However, we must understand that in the teaching profession, change for many is difficult to implement and may receive some reluctance from other professional teachers.

Problem Statement

Student academic achievement and attitude could be greater when problem solving-based learning instruction versus lecture-based direct instruction is used. The problem with lecture-based direct instruction is the fact that the teacher is telling the students how a mathematical problem is solved rather than the student experiencing and constructing his or her learning experience. With problem solving-based instruction, the teacher can focus on a mathematical problem that sparks the interest of the students within a given class. Students can then work in cooperative learning groups to investigate a specific theorem or solve a given problem.

CHAPTER TWO

LITERATURE REVIEW

Benefits of PBL vs. DI

Much of the research conducted revealed an abundance of authors stating the important benefits that PBL has on student learning. There was a degree of difficulty in finding research-based and evidence-based experiments that would support this claim. Furthermore, narrowing the topic to compare PBL with lecture-based DI proved to be even more difficult. However, students who were taught using the problem solving-based instructional model did experience significant conceptual changes than did students who experienced the traditional-lecture type teaching method (Chang & Barufaldi, 1999, p.373).

Based on the problem stated above, there seems to be a need to research which mode of instruction could yield more interest from a typical student. Not only do teachers want their students to be comfortable with the content material that they teach in class, they desire students to be confident and satisfied with all the mathematical content being discussed in class. The students in PBL curricula report being more satisfied with their learning and confident in their understanding than those in traditional curricula (Albanese and Mitchell, 1993; Hmelo, 1994; Vernon and Blake, 1993). Another study found that the emphasis of the problem solving-based model on application, problem-solving skills and thinking skills might have been the major factor contributing to the overall increase in earth science achievement among students in the treatment group (Chang & Barufaldi, 1999, p.383). Although this problem's primary research is on mathematical content of subtopics found in a normal Geometry curriculum, it was assuring to know that PBL had potential in influencing human behavior toward gains in student achievement.

Although students may possess the conceptual knowledge of much of the mathematical content taught within a given class, many students continue to struggle when applying this knowledge to solve challenging problems. Even when instilling high expectations for all students, students still struggle to apply their knowledge to problem-based scenarios. Luckily, there was a problem solving-based instruction model that significantly improved the achievement of students, especially at the application level (Chang & Barufaldi, 1999, p.373). Since this experiment yielded positive results that is of special importance to this particular research proposal, a researcher should feel confident in proving the many benefits of PBL versus DI, especially how it relates to high-stakes tests that incorporate a majority of application-based questions.

One barrier to using PBL in more diverse settings is the lack of a sufficient number of skilled facilitators. Classrooms have more students than one person can easily facilitate, and learning to facilitate well is a challenge (Derry et al., 2001). With the many professional development seminars that teachers have attended over the years, it is remarkable of the lack of PBL seminars being offered. Because of financial constraints of local towns and cities, it seems that many are forced to increase student to teacher ratios, making it even more difficult for skilled teachers to attempt to facilitate PBL within their own classrooms. Some teachers even resort back to lecture-based instruction despite all the research that support PBL instruction over DI. Lectures are not sufficient to stimulate in confronting students' existing naïve conceptions and to modify their alternative frameworks (Brumby, 1984).

There are some veteran teachers that seem to be stuck in their old ways of teaching. Those who are unwilling to change and adapt may use some of the following activities which include: lecturing or telling students how to solve a given problem, instill the paradigm that all

problems have a certain algorithm that should be used to solve them, give specific rules to solve specific types of problems, and act condescending to students that struggle with math. Many educators pass on to their students that math is a set of rules that require memorization, computation problems are always solved by using algorithms, problems always have one correct answer, and people who use mathematics are geniuses (Mtetwa & Garofalo, 1989). With much of the research pointing towards PBL as being the better bet, it was necessary to find programs, interventions, and theories that supported it.

A repertoire of best practices must be at the forefront to facilitate essential knowledge, attitudes, and skills for all children (Adeeb & Terrell, 1999, p. 27). Constructivism (also known as learning theory) is a theory where humans generate knowledge and meaning from their experiences. The role of a classroom teacher is to act as a facilitator of knowledge. It would be the educator's job to create meaningful activities for students to engage in during class. Students should be presented with problems that need to be worked out within a cooperative group setting. While students worked on the problems, the teacher facilitator would be responsible for roaming around the room to ask investigative questions that would lead to student discussion within their groups. In theory, the students would be responsible for their own learning and constructing knowledge from the experiences that occurred in the classroom. The teaching approach shows its constructivist character by starting from students' prior ideas, and by promoting conceptual change through practical experiments and classroom discussions (Thijs, 1992). Basically, the need for students to discuss the problems with their peers is a basic practice that should be implemented with PBL.

Many medical schools have transitioned from lecture-based instruction to problem-based instruction. Again, instead of a professor telling you specific material that you should know, the

class is more structured around a set of problems that groups of medical students are responsible for solving. In order to solve these problems, it is necessary for them to work collaboratively, discussing different approaches in order to solve the given problem. Much research shows that superior processing of didactic material occurs when a student has first engaged in analyses of pertinent dimensions of the phenomena that are to be explained (Schwartz & Bransford, 1998). But in order to encourage student engagement, a problem posed by the teacher must be both appealing and interesting to the student.

Student-Interest with PBL

Creating a problem just for the sake of making one that involves math seems silly. After scanning through many different mathematics textbooks, one would notice that some problems are a far cry away from piquing students' interests. When relating math to specific activities that seem interesting to a majority of students in the class, they can finally see the value of math in everyday living (Adeeb & Terrell, 1999, p. 30). Not only should a student be given a relevant problem to work on, they must also feel confident in their ability to solve problems.

Nothing is more frustrating to a student than not being able to get a solution to a problem. Without proper motivation, a student may give up on a problem. It is important for each child to feel successful and accepted, recognize his or her potential and ability to learn, and recognize the relevance of mathematics both within and outside the classroom (Adeeb & Terrell, 1999, p. 27). Many teachers may find it difficult to create meaningful problems that can relate to and spark interest with students.

A problem is not a problem unless the learner is interested in solving it. Thus, problems and problem solving are not defined solely by appearance or subject matter, but rather by their capacity to evoke in students a genuine interest in solving them (Polya, 1962; Schoenfeld, 1989).

Teachers need to be given more time to research problems that a majority of their students would be interested in solving. In addition, teachers need to allow much of the classroom instructional time for students to work on solving select problems.

Students should know what it feels like to be completely absorbed in a problem, yet they seldom experience this feeling in school (Bruner, 1960). Effective teachers are able to hold high expectations for all learners within their classroom, and create a learning environment that is conducive for student collaboration in order to immerse them into meaningful problems that they are interested in solving. Teachers need effective research-based practices in order to foster this type of environment.

To foster flexible thinking, problems need to be complex, ill-structured, and open-ended. In order to support intrinsic motivation, they must also be realistic and resonate with the students' experiences (Hmelo-Silver, 2004, p. 244). This statement relates to a primary basis for PBL instruction. This might be the "key" to activating students' interests to solving problems which can in turn increase student achievement.

Bottge asked readers to imagine a key and a lock as a theory of the "key" to learning. With this simile, every notch in the key moves a specific pin and once all the pins are aligned correctly, effective learning can then finally take place. However, even if all but one pin is aligned, the structure in which you are trying to open will not open. The model draws on almost a century of learning theory (key) on which to base more appropriate instruction to activate the minds of students (Bottge, 2001, p.103). The need to activate the minds of students hinges on teachers being able to create meaningful problems for which they are to solve.

Despite being an old article, Wethemimer advised teachers to teach as little as possible and challenge students with tasks they can deal with themselves (Wertheimer, 1959). Again, the

focus of PBL is that the teacher is a facilitator in the classroom. He or she is required to maintain a learning environment where students construct knowledge from the meaningful problems and activities that they engage in within the classroom. Finally, when a teacher creates a student-centered environment that encompasses problems that are interesting to their students, intrinsic motivation can occur which can further lead to an autonomous learner. Intrinsic motivation occurs when learners work on a task motivated by their own interests, challenges, or sense of satisfaction (Hmelo-Silver, 2004, p. 241). Intrinsic motivation is one factor that is needed to create autonomous learners within PBL instruction.

Creating Autonomous Learners with PBL

In 2000, the National Council of Teacher of Mathematics released this following statement which highlights many of the factors that influence human behavior on the topic of Problem-Based Learning. This statement was released in their publication *Principles and Standards for School Mathematics*:

Students learn more and better when they 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 out things on their own, flexible in exploring mathematical ideas and trying alternative paths, and willing to persevere

(National Council of Teachers of Mathematics, 2000)

Humans have the ability to be sentient to what they learn and how they learn. Some coin this process as the following phrase: “Knowing about knowing.” Unfortunately, it takes a great deal of self-awareness for this to occur. Self-reflection on how an individual learns could

possibly help students evaluate their thinking process. However, many times in a classroom setting, there is inadequate time to devote to reflective learning or this valuable self-evaluation tool is not known to the learner. Metacognitive strategies are also important for the third goal of developing self-directed, lifelong learning skills. These are the skills that enable autonomous learning (Hmelo-Silver, 2004, p. 240). Teachers need to offer this valuable tool to their students and insist that they actively participate in reflective learning as often as possible.

One approach to encourage reflective learning is to have students maintain a journal. Each learner can free-write on specific journal prompts that the teacher provides. Some examples of journal prompts could be: What was your thought-process in solving the given problem, what kind of patterns did you use to solve the given problem, what method did your group use to find the solution to the given problem, how did you personally structure your learning during this class period.

At the completion of a problem, students reflect on what they have learned, how well they collaborated with the group, and how effectively they directed their learning (Hmelo-Silver, 2004, p. 247). It is very important that in PBL, students are asked to put their knowledge to use and to be reflective and self-directed learners (Hmelo-Silver, 2004, p. 239). The aforementioned are two main factors that contribute to student autonomous learning. In addition to the necessity that the student is able to use metacognition, a student must also possess a substantial amount of prior knowledge. A student must be able to activate this prior knowledge in order to solve challenging problems and connect additional new information to already existing information.

Organized Prior Knowledge Schema with PBL

Many factors can attribute to a student not possessing a substantial base of knowledge for the grade level they are currently in. Some say previous teachers may not have prepared the

student for the rigorous math encountered in the current grade level. Others may say that the student barely got by with a subpar grade in previous math classes, which contributed to learning gaps of prior knowledge. Student failure to activate and apply prior knowledge can be largely attributed to the poor quality of their mathematical knowledge base (Resnick & Ford, 1981). This factor is not only influencing their behavior in the ability to solve challenging problems, but it can also be a barrier to future student learning in PBL instruction.

If a student lacks a substantial amount of prior knowledge, it can be more difficult for that particular individual to work in a cooperative learning environment. However, new concepts can be learned by other members of the group. Also, much of the diversity of prior knowledge that a student brings to the classroom can remain untouched. Prominent in modern theories of teaching and learning is the recognition that students bring to the classroom a rich store of knowledge untapped by conventional teaching practices (Bottge, 2001, p.106). Again, further evidence supports why teachers should give meaningful problems that students find interesting to solve and give adequate time for students to work collaboratively. Cooperative groups can give students an opportunity to discuss problems with one another.

The two following statements describe two methods that can help students recall and organize prior knowledge schema in a problem-based learning environment: Discussing problems in a PBL group activates relevant prior knowledge and facilitates the processing of new information (Schmidt et al., 1989) and teaching should foster a classroom culture that promotes the growth and transmission of ideas generated from students' own pool of knowledge and expertise (Baroody & Hume, 1991). Said studies highlight evidence-based research that promotes best-practices for organized prior knowledge schema.

One study done by Capon and Kuhn (2004) states:

Our data provide the strongest support for integration as the locus of differential effects of problem-based and traditional instruction. Students who experience problem-based instruction more often were able to integrate newly acquired concepts with existing knowledge structures that had been activated (p.74)

Another study focused on geometric knowledge and how it relates to a prior knowledge schema. This research is useful to defend the belief that problem-based learning is beneficial in increasing students' scores on high-stakes tests. It appears that students who structure their prior geometric knowledge into chunks or schemas also develop an understanding of when and how to deploy that knowledge productively during problem solving (Chinnappan, 1998, p.214). This study compared two groups of pupils. One group contained high-achievers and the other group contained low-achievers. Basically, high-achievers were able to construct their prior knowledge into a more organized form of chunks of information (what the author referred to as schema). Not only does a student need to be able to recall prior knowledge, but must also be able to work together with peers in a collaborative and cooperative learning environment.

Cooperative Learning with PBL

The following statement highlights three factors that relate to human influence on the topic of cooperative learning.

Cooperative learning (a) promotes self-esteem, motivation, and achievement for female and minority students, (b) improves student attitudes toward their classmates, particularly those from backgrounds differing from their own, and (c) lessens boundaries

created by gender and race (Slavin, 1986; Catsambis, 1994; Rech, 1994)

As stated from previous topics, it is necessary for a learner to feel confident in being able to solve problems, have intrinsic motivation to persevere through difficult and challenging problems, and create a level playing field in equitable instruction so that learning takes place. However, some barriers of learning can get in the way.

Vygotsky believed that higher forms of intellectual functioning arose out of cooperation and collaboration with other people (Vygotsky, 1978). But not all students are team players. Many of the following barriers that teachers encounter when facilitating cooperative learning within their classroom include: student reluctance to get into mixed-ability groups (rather than forming groups with their friends), one smart student doing all the work within the group, posing a challenging problem that the students feel is too difficult so they do not even attempt the problem, and the list can go on and on.

Small group structure helps distribute the cognitive load among the members of the group, taking advantage of group members' distributed expertise by allowing the whole group to tackle problems that would normally be too difficult for each student alone (Pea, 1993). Ideally, the previous statement would work in a perfect-world and perfect classroom. Is it realistic? That can be argued. However, instituting best-practices can help.

Enhancing conceptual change within students is one of the primary goals of PBL instruction. Since students have the opportunity to discuss a problem with one another, new ideas formed at the table during problem solving can increase student acquired knowledge and form new ideas and concepts on top of old concepts. Based on research done by Lonning, Thorley, and Treagust they were able to conclude that cooperative learning strategies enhance conceptual

change instruction (Lonning, 1993) and interpersonal conflicts and interactions can stimulate pupil's conceptual change (Thorley & Treagust, 1987).

Effective teachers allow a majority of their instructional time to be devoted to cooperative learning. In order to do this, rituals and routines need to be established the first few weeks of school. Once students understand the rituals and routines within the classroom, the teacher will be able to better facilitate cooperative learning within the classroom. Again, evidence shows that groups who have previously discussed the topic produce significantly more explanatory statements (Schwartz & Bransford, 1998). Much of the make-up of PBL instruction is intrinsic self-interest and motivation, being an autonomous learner, having a sound organization of prior knowledge schema, and being able to play an active role in cooperative learning. With all the pieces of the puzzle finally together, a student will be able to learn, achieve, and perform better on high-stakes tests.

Increased Student Learning, Achievement, and Performance with PBL

The major theme in undergraduate secondary education classes was the effectiveness of teachers. In order for a teacher to be effective, a teacher must set high expectations for all learners within the classroom. A subtle factor that influences student performance, especially that of difficult-to-teach students, is teacher expectation (Rosenthal & Jacobson, 1968).

Another philosophy that a student teacher may have acquired during undergraduate studies is that new and upcoming teachers had to be the catalyst for change in the education industry. The way we were taught in school should not be the way we continue to teach students. With that, many of the modes of instruction that were used and still continue to be used in today's classroom do not increase student learning, achievement, or performance on high-stakes tests. Bottge refers to students where their intuitions have been suppressed or erased by emphasis

on heuristics, strategies, and rote memorization (Bottge, 2001, p.107). More problem-based learning instruction may be able to increase students' scores on high-stakes tests. But barriers to PBL do exist.

The following statement explains how it can be difficult for older administrators to conduct evaluations on student learning and teacher effectiveness. Much of this difficulty is from past educational experiences of the observer, current educational practices that the observer is used to within a classroom setting, and a lack of knowledge of the reform of mathematics instruction that is happening today.

Understanding what is happening in today's math classes and making judgments about its adequacy may be especially challenging for veteran principals, since the kind of instruction there may be very different from what they had as students or how they taught math when they were teachers (Nelson & Sassi, 2007, p.54)

Based on the following research, one can conclude that PBL instruction is a best-practice that can benefit students' learning, achievement, and performance on high-stakes tests. In one experiment, the PBL students scored higher on a multiple-choice test than traditionally instructed students (Gallagher & Stepien, 1996). Another design experiment demonstrated that PBL students showed greater gains on both short-answer tests and drawing task than students in comparison classrooms (Hmelo et al., 2000). Within both experiments, significant gains in student performance were measured. The traditional instruction used in both experiments was lecture-based DI. Other than intrinsic self-interest and motivation, being an autonomous learner, having a sound organization of prior knowledge schema, and being able to play an active role in

cooperative learning, something somewhat out of a student's control of his or her learning experiences might be monetary.

Role of Socio-Economic Status with PBL

Some students need a follow-up intervention in order to close the gaps of previous learning and conceptual deficiencies. This intervention may require a one-on-one tutor approach. However, students who have parents that do not have access to sufficient monetary resources to pay for these services might be left behind. Dossey, Mullis, and Jones found that low socio-economic students are too often given fewer opportunities and less encouragement to learn mathematics (Dossey, Mullis, & Jones, 1993).

It is only such students, whose parents are educated and have high socioeconomic status, who show good mathematics performance because such parents can offer the necessary academic support to their children (Joshi, 1995). Again, the barrier in this case is the access of disposable income to pay for the needed services. A student can either be lucky to be a part of a well-to-do family or unfortunate to not have a family with such a high socio-economic status.

Necessity of Additional Research on PBL

It was difficult to filter out the numerous hits of medical problem-based learning instruction. This was the majority of research that has been conducted on the topic of PBL. The claims of PBL advocates are not all supported by an extensive research base, and much of the research base has been restricted to higher education, predominantly in medical schools. There is little research with K-12 populations (Hmelo-Silver, 2004, p. 260).

Much of the evidence of the lack of research done on PBL for students within grades K-12 can be found in the following two statements: We are even further from identifying and appreciating what these students can accomplish in out-of-school settings (Bottge, 2001, p.109)

and there has been little work [on research of PBL] with younger students (Hmelo-Silver, 2004, p. 252).

This lack of research could be because there is a deficiency of funding and grants available for this type of research, only a small pool of scholars are available to do this type of research, or the reluctance that public schools may have for using students as test subjects.

To conduct controlled investigation of different forms of problem-based learning in different populations is a demanding agenda, but the enormous effort educators are currently investing in problem-based learning initiatives suggests that it is an agenda worth the effort required (Capon & Kuhn, 2004, p.75). In all, this contribution to the field of education will hopefully benefit future researchers and scholars.

CHAPTER THREE

RESEARCH DESIGN

If a student is taught with a problem-based learning instructional environment (PBL) his or her achievement (test score) and attitude on a standardized high-stakes test will be higher than a student who is taught with a lecture-based direct instructional environment (DI).

The experiment was based on an evaluation of pre and post tests modeled along the same structure and environment as the Rhode Island's high stakes math exam called the New England Common Assessments Program (NECAP). Student surveys quantified individual attitude toward each instructional approach.

The curriculum has been restructured based on the given instructional approach (PBL vs. DI). It was based on a two-week unit on a specific subtopic found in Geometry. One class was taught using a problem-based learning instructional method (PBL) and the other class was taught using a lecture-based direct instructional method (DI).

Purpose

The main purpose of this study was to investigate the effects of problem solving-based instruction versus lecture-based direct instruction on student academic achievement and attitude. Furthermore, it took into account the effectiveness of what Problem-Based Learning (PBL) has on high stakes standardized mathematics exams.

As cited from the literature review, many scholarly papers make bold statements on the benefits of problem-based learning and problem-based instruction; however, the amount of research done on this topic is minute. This research has shown that this type of instruction benefits students and can increase student achievement on high-stakes tests. The research findings will be contributed to the small amount of research already done on a very popular

topic. Hopefully, this can be a catalyst in changing some teacher's way of teaching, or at the very least, create discussions in teacher lounges for or against the thesis topic.

Instructional Environment / Description of Learners

The age range of students is fifteen years old to seventeen years old. The majority of the students are sophomores in High School. The groups of students were mixed-ability where most are college bound. All classes described were at the academic level. The majority of students were white-Caucasian. The prior knowledge that each student had depends on the track they chose from middle school. One particular student may have taken Algebra I during their freshman year in high school, therefore they will be enrolled in Geometry with an Algebra I base of knowledge. Another particular student may have taken Algebra I in eighth grade and Algebra II during their freshman year in high school, therefore they will be enrolled in Geometry with an Algebra I and II base of knowledge. The motivation of the students are typical of a rural student who is college bound. The socioeconomic status is a majority of middle to middle-upper class families. Finally, the gender ratio was close to forty-five percent males to fifty-five percent females.

Learning Context

The classroom teacher has established a very structured learning environment where during the time of data gathering, students knew the rituals, routines, and classroom procedures. Each class was ran as a workshop model. The financial resources were typical of a rural community. However, budget constraints has increased student to teacher ratios within the classes. The Geometry book edition date is in the year 2002. Recently, administration has focused more on gathering data based on formative assessments. These formative assessments has been used as information for the teacher to either re-teach a certain skill, or change his or her

way of teaching a given topic based on the results. Finally, students understand that in order to graduate high school, they must pass with a score of proficient on the NECAP (the state of Rhode Island has adopted the NECAP Test to be used as a high-stakes test). The NECAP math score represents a third of a student's graduation requirement.

Appropriateness of Approach

The methodological approach was an experimental quantitative design. A qualitative approach is not sufficient because part of the research focus is on the achievement gains of students on high-stakes tests which indicate the use of measurable test scores. In addition, the independent variable was the instructional approach and the dependent variable was student achievement and attitude. The fact of having an independent and dependent variable leans more towards an experimental design. Lastly, the data analysis was quantitative in nature since test scores and Likert scale numbers were used and are measurable. The necessity of having to do a statistical analysis using measures of central tendency, a t-test or analysis of covariance (ANCOVA), and a chi-square analysis ultimately validates this research approach as being quantitative and experimental in nature.

Research Questions and Hypotheses

- 1) Is student achievement higher when a problem-based learning instructional environment is used rather than a lecture-based direct instructional environment?
- 2) Is student attitude higher when a problem-based learning instructional environment is used rather than a lecture-based direct instructional environment?

If a student is taught with a problem-based learning instructional environment (PBL), then his or her achievement (test score) on a standardized high-stakes test will be higher than a student who is taught with a lecture-based direct instructional environment (DI).

If a student is taught with a problem-based learning instructional environment (PBL), then his or her attitude on a standardized high-stakes test will be higher than a student who is taught with a lecture-based direct instructional environment (DI).

Role of the Researcher / Bias of Researcher

The researcher is also a classroom teacher. He or she had access to two academic classes within the same discipline, i.e. two Geometry Academic Courses. One course was taught by the researcher with a problem-based learning instructional environment, the other class was exposed to a lecture-based direct instructional environment. The researcher administered the instructional method within each class, administered pre and post tests, administered student surveys, collected all the data, and analyzed the data. The bias the researcher may have characterized includes the predisposed notion of the type of instructional method he or she believes will prove to benefit student achievement and attitude prior to the experiment. Also, because the researcher was the teacher on record, he or she may have wanted to ensure students' success no matter which instructional method was used. Lastly, depending on the analysis the researcher chose to use, the data analysis may have been skewed leading to a faulty conclusion.

Target Audience / Role of Participants

The participants included twenty five students in one Geometry class and a group of twenty five student participants in another Geometry class. Students were exposed to a specific type of instructional method (one class with PBL and the other class with DI). A pre-test was administered as a baseline of their knowledge and a post-test was administered at the end of a two-week unit on a given subject in the school's Geometry Curriculum. These tests closely resembled that of the state's high-stakes tests in mathematics. In addition to the pre-test and post-test, a survey was handed to each student to fill out so that the researcher could analyze their

attitude with the given instructional method and their attitude during the pre and post tests. The target audience for this type of research would be administrators and teachers who wish to find valid research data and conclusions on the benefits of PBL versus DI.

Variations of Groupings

The grouping will be heterogeneous mixed-ability. The gender ratio as stated above has been resembled closely to that of both of the Geometry classes within this experiment. No students were used from an Honors Geometry class.

CHAPTER FOUR

METHODOLOGY

This was an experimental quantitative design experiment. The independent variable was the instructional approach and the dependent variable was the student achievement and attitude. Two Geometry classes were used. One class was taught for two weeks using a PBL instruction and the other class was taught for two weeks using DI. Students were given a pre-test to set a baseline of knowledge and a post-test after the two weeks to determine either the gains or losses in student achievement. Finally, student surveys were given out to determine the student attitude toward each of the types of instructional methods. The instruments used were the pre-test and post-test administered to the students in both classes. These tests were multiple-choice, and mirrored along the same type of questions as given on the Rhode Island NECAP high-stakes exam in mathematics. Another instrument was a student attitude survey which had answer choices found on a typical Likert scale. Questions were modeled along to inquire about a student's attitude toward a specific type of instruction.

Instruments

The pre-test and post-test contained the following Geometry content: introduction to properties of triangles, triangle sum conjecture, properties of special triangles, triangle inequalities, and triangle congruency shortcuts. Both the pre and post test was identical and paper-based. Both tests included a total of thirty-four multiple choice questions with the breadth of the content mentioned previously. For each multiple-choice question, each had four possible answers. The types of questions mirrored the ones found on our typical NECAP high-stakes state of Rhode Island mathematics assessment. The directions for the tests were included on the top of each assessment packet that a student received. The teacher also read these directions out loud,

as the same format for a typical testing environment for the NECAP. See Appendix A for the full text of the achievement test.

The student questionnaire survey included a Likert scale. The number of questions found on the student questionnaire survey was twenty. The standard measure ranges from the number one being the lowest to the number six being the highest. The scales were from one to six: Strongly Disagree, Moderately Disagree, Slightly Disagree, Slightly Agree, Moderately Agree, and Strongly Agree. See Appendix B for the full text for the attitude survey.

Procedures

The researcher of this experiment was also the classroom teacher. The researcher developed a total of ten lesson plans. The lesson plans contained the following content: 1) introduction to properties of triangles, 2) triangle sum conjecture, 3) properties of special triangles, 4) triangle inequalities, and 5) triangle congruency shortcuts. Each of the specific content topics just mentioned was the focus of each of the five lesson plans. The researcher has created five lesson plans focusing on PBL, and five lesson plans focusing on DI.

The length of the study was fourteen academic days and the length of time for a block period was eighty-five minutes. Because of block-scheduling, where an academic class meets every other day, each class was exposed to this experiment for a total of seven academic days over a period of roughly three calendar weeks. The first of the seven days consisted of the student participants taking the pre-test in the allotted time. The second through sixth day consisted of the students being exposed to the specific type of instruction, PBL or DI. The seventh day students took the post-test. At the end of the class, students were given the questionnaire survey to take home and complete for homework. Students were not be penalized for not completing this survey, nor was this survey graded. Each instructional day focused on the

given geometry topic as mentioned before, for instance, the first day of instruction focused on an introduction to the properties of a triangle.

The testing environment was identical to the environment found during NECAP testing. The tests were administered in the teacher's classroom during the period that the particular Geometry class met. Student participants were given a maximum of one hour to complete the thirty-four question multiple choice assessment. Test directions were printed on the top of the pre-test and post-test assessment packet and read out loud by the teacher. The pre-test was administered the first day of the experiment, and the post-test was administered the last day of the experiment. The student questionnaire survey was completed by each participant at home for homework on the last day of the experiment after the post-test was administered.

Types of Data

An ordinal variable type of data was collected from the student attitude surveys using a Likert scale. A ratio variable type of data (test raw scores) was collected from the high-stakes modeled NECAP pre-tests and post-tests.

Types of Data Analysis Used

From the student surveys using a Likert scale, the ordinal data was analyzed by finding the median of the given data set. From the pre-tests and post-tests using a raw score, the ratio data was analyzed by finding the mean.

A t-test was used to analyze the quantitative mean values of both the pre and post tests. The t-test was used to check to ensure that there was a statistical difference between the mean values of the pre and post tests from the experimental and control group. The researcher has assumed, based on the fact that random sampling for the experimental and control group occurred, there is no variance of beginning achievement on the Geometry topics covered in the

intervention between the two groups and the pre-test and post-test scores are normally distributed. Both the experimental and control group can be considered equivalent. However, if a variance of beginning achievement between the two groups did occur, an analysis of covariance (ANCOVA) would have been used on the pre-test and post-test scores in order to adequately gauge learning achievement. This analysis, in essence, would have been used to handicap the scores of one of the particular groups to account for the variance in beginning achievement.

A chi-square analysis was used on the quantitative values on the Likert scale to adequately gauge attitude. Microsoft Excel with an XLSTAT add-in was used in order to keep track of all the data and the function capabilities was used within this program to do the statistical analysis of the measures of central tendency, t-test, ANCOVA (which was not needed), and chi-square analysis.

Sampling Techniques

The sampling technique performed was a random sampling. Prior to the start of a new school year, student's names are placed in a computer program that randomly assigns them to a specific academic class. The student population in this experiment is focused on academic students (not honor students). The gender ratio as mentioned previously will still hold true for both Geometry classes. Again, the sample size was around fifty participants. The confidence interval level was estimated at plus or minus fourteen percent based on the sample size. Since random sampling provides a more credible and unbiased pool of participants (since the only influence is chance), this lead to a more solid experimental design. This sampling technique was appropriate because all academic Geometry students in this particular high school had an equal chance of participating in this experiment. Since the researcher has wished to generalize the

effectiveness of student achievement and attitude with PBL for academic Geometry students this makes the data analysis, findings, and conclusions much more valid.

Rationale for Analysis Chosen

Finding the measures of central tendency using an Excel spreadsheet including the mean and median has helped the researcher calculate a more rigorous set of statistical analysis. Since ordinal data was collected through the student questionnaire surveys, the nature of ordinal data leads to using the median of the data set. Also, since the ratio data was collected from pre-test and post-test scores, the nature of this type of data lead to calculating the mean only.

A t-test ensured there was a statistical difference between the mean values of the pre and post tests from both the experimental and control group. Since a variance of student achievement was not found, than an analysis of covariance (ANCOVA) was not necessary for the pre-test and post-test data. The pre-test helped determine the baseline of student achievement and a t-test was used to find whether there was significant differences in the mean values for the post-test.

A chi-square analysis was necessary for the survey questionnaire Likert scale results because it is a test for deviations of observed frequencies from expected frequencies. Any items where there was a significant difference was examined to form an explanation of the frequency of differences.

Interpretation of Analysis Results

While analyzing the mean scores of the pre-test and post-test data using a t-test the researcher was looking to get the value of p to be less than or equal to 0.05, or in statistical terms, $p \leq 0.05$. The t-score of the given set of data was compared with the t-value found on a student's t distribution table chart. The t-value that was chosen was dependent upon the degrees of freedom found from the sample of data and the margin of error which the researcher has

chosen as $p \leq 0.05$. If the t-score is greater than the t-value, then the researcher could assume that a larger population would have a significantly higher value as a mean. In addition, if the mean of the experimental group is significantly greater than the mean of the control group, then the researcher could accept the given hypothesis. If this was not the case, the researcher must reject the given hypothesis.

If the researcher actually found a variation in student intelligence, an ANCOVA analysis would need to have been done. While analyzing the covariance using ANCOVA, the researcher was looking to get the probability corresponding to the F value to be lower than 0.05, or in statistical terms, $p < 0.05$. Again, while using Excel with the XLSTAT add-in, a Fisher's F test will be used to find this value. If the p was less than 0.05 then the researcher can conclude that the analysis highlights that the data is significant. In addition, if the mean of the experimental group was significantly greater than the mean of the control group, then the researcher could accept the given hypothesis. If this is not the case, the researcher must reject the given hypothesis.

While analyzing the student questionnaire surveys with a chi-square analysis the researchers was looking to get the value of p to again be lower than 0.05, or in statistical terms, $p < 0.05$. If the p was less than 0.05 then the researcher can conclude that the analysis highlights significant gain in student attitude, and the researcher would be able to reject the null hypothesis. In addition, if the median of the experimental group was significantly greater than the median of the control group, then the researcher could accept the given hypothesis. If this was not the case, the researcher must reject the given hypothesis.

CHAPTER FIVE

CONCLUSION

The most intriguing and labor-intensive part of this research proposal would have to be the literature review. While going through over thirty scholarly journal articles and essays, it was fascinating to see other researchers so passionate about student achievement within the classroom. These researchers seemed to share similar beliefs and philosophies that I too believe in. It was also assuring to know that the majority of the instruction that I use in my classroom parallels with the same instruction that has been proven through research to increase student achievement.

It was difficult at first to find common themes to discuss in my literature review. It was my first time having to read through an abundance of material, highlight significant points in each, and fit these significant points under specific topics within one paper. Not only was this process time consuming, it was mentally exhausting. Luckily, through perseverance and an abundance of caffeinated coffee, the task of compiling all of my thoughts with the thoughts of other researchers was done.

In the end, I hope that I have done my duty as a neophyte teacher to better myself professionally in my educational field, better the achievement of my students by implementing research-based best-practices within my classroom, and better the possibility that other teachers will adopt a problem-based learning environment for their classroom rather than a lecture-based environment. I truly believe that PBL can increase student achievement and I am excited to say that the research conducted supports my theory.

Data Results

Students who participated in this study were randomly chosen and were randomly placed in the researcher's classroom sections. Even though students were randomly chosen and placed, the researcher still had a concern that there would be a variation of intelligence between the two classes. However, based on the present data of central tendencies on the pre-test raw scores the mean raw scores between both classes were identical. With further inspection, a comparison between the minimum, first quartile, median, third quartile, and maximum scores showed little to no differences as well.

Table 1

Sample	Frequency	Mean	Variance	Standard deviation	Standard-error
PBL Pre-Test	17	15.588	13.507	3.675	0.891
DI Pre-Test	17	15.588	10.257	3.203	0.777
Sample	Minimum	First Quartile	Median	Third quartile	Maximum
PBL Pre-Test	8.000	14.500	16.000	17.500	23.000
DI Pre-Test	8.000	14.000	15.000	18.000	22.000

During a review of the post-test scores, a significant difference between mean raw scores was present. A student's one-tailed right-tailed t-test was conducted with both independent samples with an assumption that the two theoretical variances are equal. The p-value was found to be under 0.05. In addition, a student's one-tailed right-tailed t-test using the Satterthwaite's method was conducted with both independent samples with an assumption that the two theoretical variances are not equal. The p-value was also found to be under 0.05.

Table 2

Student t-test		Satterthwaite's method	
t (observed value)	1.705	t (observed value)	1.732
t (critical value)	1.699	t (critical value)	1.709
DF	29	DF	24
One-tailed p-value	0.049	One-tailed p-value	0.048
Alpha	0.05	Alpha	0.05

The class taught using PBL had a higher raw mean score than the class being taught with DI. The researcher also looked at the central tendencies of the post-test raw scores. With further inspection, a comparison between the minimum, first quartile, median, third quartile, and maximum scores showed higher student achievement in raw scores with the PBL class versus the DI class.

Table 3

Sample	Frequency	Mean	Variance	Standard Deviation	Standard Error
PBL Post-Test	15	23.000	7.857	2.803	0.724
DI Post-Test	16	20.625	21.717	4.660	1.165

Sample	Minimum	First Quartile	Median	Third Quartile	Maximum
PBL Post-Test	19.000	21.000	22.000	25.000	29.000
DI Post-Test	12.000	17.500	20.000	24.000	28.000

The results of the student questionnaire survey were categorized under four headings which included: Instructional Method, Activities, Cooperative Learning Groups, and Homework Assignments. Under each category, five questions were asked to determine student attitude. A chi-square test and a chi-square likelihood ratio test were conducted for each category. The strongly disagree option under the Likert-Scale has been disregarded in each of the four

categories because the number of responses fell below five for every chi-square contingency table.

Instructional Method

The following contingency table marked as Table 4 depicts the number of responses under each Likert-Scale option for the Instructional Method category. A bar graph directly below this table marked as Figure 1 visually depicts the data results.

Table 4

Instructional Method	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
PBL	0	0	16	48	15
DI	7	12	26	29	5

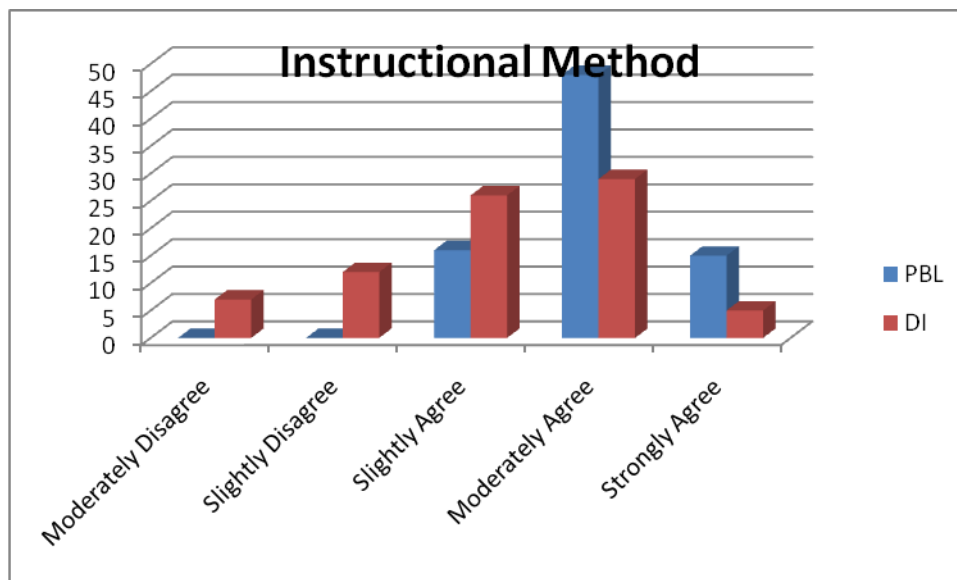


Figure 1

Based on Figure 1, one can see that a majority of responses under moderately disagree and slightly disagree came from the DI class. Also, a majority of responses under moderately agree and strongly agree came from the PBL class. The percentage of responses for the moderately disagree option was one-hundred percent for the DI group and zero percent for the

PBL group. The percentage of responses for the slightly disagree option was one-hundred percent for the DI group and zero percent for the PBL group. The percentage of responses for the slightly agree option was thirty-eight percent for the DI group and sixty-two percent for the PBL group. The percentage of responses for the moderately agree option was sixty-two percent for the PBL group and thirty-eight percent for the DI group. The percentage of responses for the strongly agree option was seventy-five percent for the PBL group and twenty-five percent for the DI group. The responses for the slightly agree option indicates a turning point in the data. This turning point symbolizes a shift in student attitude where the first three option responses were predominantly from the DI class and the last two option responses were predominantly from the PBL class. The shift occurs when PBL and DI switch places as majority leaders. PBL claims majority for the last two options in favor of the instructional method. This trend is seen in the next two categories as well.

One highlight worth mentioning is the fact that there were three times as many responses in favor of PBL as an instructional method for the strongly agree option. Also, no PBL responses were chosen for the first two options whereas only DI responses existed.

The following table marked as Table 5 depicts data from the chi-square test and the chi-square likelihood ratio test for the Instructional Method category. Both p-values were found to be under 0.05.

Table 5

Chi-Square Test:		Chi-Square Likelihood Ratio Test:	
Chi-square (observed value)	31.069	Wilks' G ² (observed value)	38.713
Chi-square (critical value)	9.488	Wilks' G ² (critical value)	9.488
DF	4	DF	4
One-tailed p-value	< 0.0001	One-tailed p-value	< 0.0001
Alpha	0.05	Alpha	0.05

Activities

The following contingency table marked as Table 6 depicts the number of responses under each Likert-Scale option for the Activities category. A bar graph directly below this table marked as Figure 2 visually depicts the data results.

Table 6

Activities	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
PBL	0	1	13	55	11
DI	8	7	26	29	10

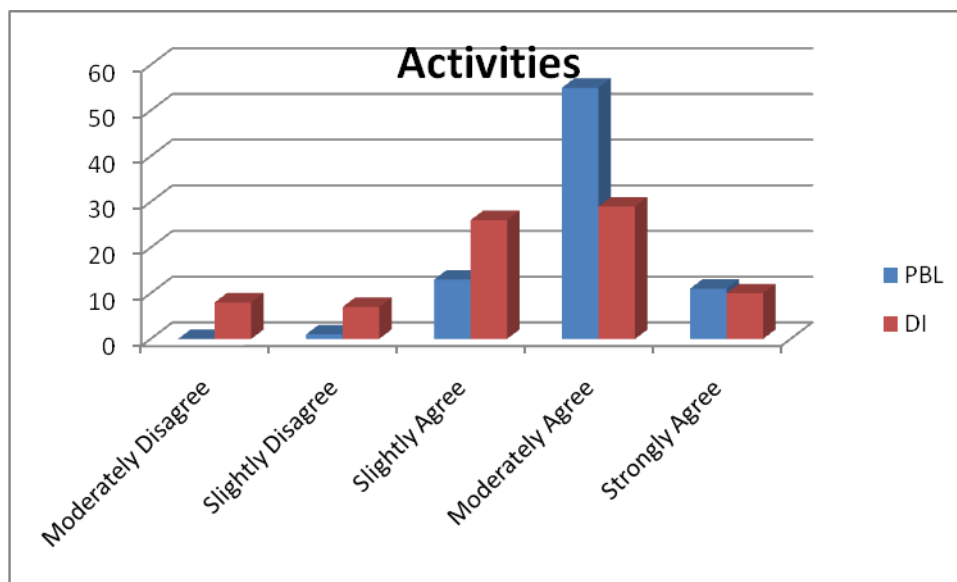


Figure 2

Based on Figure 2, one can see that a majority of responses under moderately disagree and slightly disagree came from the DI class. Also, a majority of responses under moderately agree and strongly agree came from the PBL class. The percentage of responses for the moderately disagree option was one-hundred percent for the DI group and zero percent for the PBL group. The percentage of responses for the slightly disagree option was eighty-seven percent for the DI group and thirteen percent for the PBL group. The percentage of responses for the moderately agree option was eighty-seven percent for the DI group and eighty-seven percent for the PBL group. The percentage of responses for the strongly agree option was twenty-nine percent for the DI group and ten percent for the PBL group.

the slightly agree option was sixty-seven percent for the DI group and thirty-three percent for the PBL group. The percentage of responses for the moderately agree option was sixty-five percent for the PBL group and thirty-five percent for the DI group. The percentage of responses for the strongly agree option was fifty-two percent for the PBL group and forty-eight percent for the DI group. The responses for the slightly agree option indicates a turning point in the data. This turning point symbolizes a shift in student attitude where the first three option responses were predominantly from the DI class and the last two option responses were predominantly from the PBL class. This is the same trend as mentioned in the previous category, Instructional Method.

One highlight worth mentioning is the fact that there were twice as many responses not in favor of DI activities for the slightly disagree option. Also, there were twice as many responses in favor of PBL activities for the slightly agree option, a complete switch from the previous option as mentioned before.

The following table marked as Table 7 depicts data from the chi-square test and the chi-square likelihood ratio test for the Activities category. Both p-values were found to be under 0.05.

Table 7

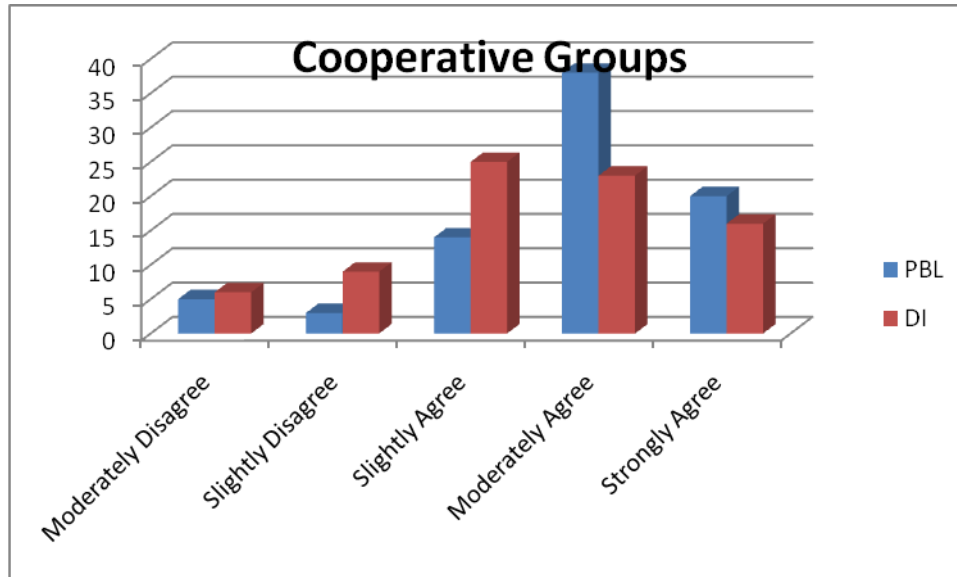
Chi-Square Test:		Chi-Square Likelihood Ratio Test :	
Chi-square (observed value)	24.929	Wilks' G ² (observed value)	28.799
Chi-square (critical value)	9.488	Wilks' G ² (critical value)	9.488
DF	4	DF	4
One-tailed p-value	< 0.0001	One-tailed p-value	< 0.0001
Alpha	0.05	Alpha	0.05

Cooperative Learning Groups

The following contingency table marked as Table 8 depicts the number of responses under each Likert-Scale option for the Cooperative Learning Groups category. A bar graph directly below this table marked as Figure 3 visually depicts the data results.

Table 8

Cooperative Groups	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
PBL	5	3	14	38	20
DI	6	9	25	23	16

**Figure 3**

Based on Figure 3, one can see that a majority of responses under moderately disagree and slightly disagree came from the DI class. Also, a majority of responses under moderately agree and strongly agree came from the PBL class. The percentage of responses for the moderately disagree option was fifty-five percent for the DI group and forty-five percent for the PBL group. The percentage of responses for the slightly disagree option was sixty-seven percent for the DI group and thirty-three percent for the PBL group. The percentage of responses for the slightly agree option was sixty-four percent for the DI group and thirty-six percent for the PBL group. The percentage of responses for the moderately agree option was sixty-two percent for the PBL group and thirty-eight percent for the DI group. The percentage of responses for the strongly agree option was fifty-six percent for the PBL group and forty-four percent for the DI

group. The responses for the slightly agree option indicates a turning point in the data. This turning point symbolizes a shift in student attitude where the first three option responses were predominantly from the DI class and the last two option responses were predominantly from the PBL class. This is the same trend as mentioned in the previous category, Activities.

One highlight worth mentioning is the fact that there were twice as many responses not in favor of DI cooperative learning groups for the slightly disagree option. Also, there were nearly twice as many responses in favor of PBL cooperative learning groups for the slightly agree option, a complete switch from the previous option as mentioned before.

The following table marked as Table 9 depicts data from the chi-square test and the chi-square likelihood ratio test for the Cooperative Learning Groups category. Both p-values were found to be under 0.05.

Table 9

Chi-Square Test:		Chi-Square Likelihood Ratio Test:	
Chi-square (observed value)	10.321	Wilks' G ² (observed value)	10.541
Chi-square (critical value)	9.488	Wilks' G ² (critical value)	9.488
DF	4	DF	4
One-tailed p-value	0.035	One-tailed p-value	0.032
Alpha	0.05	Alpha	0.05

Homework

The following contingency table marked as Table 10 depicts the number of responses under each Likert-Scale option for the Homework Assignments category. A bar graph directly below this table marked as Figure 4 visually depicts the data results.

Table 10

Homework Assignments	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
PBL	9	8	17	33	7
DI	11	7	24	25	11

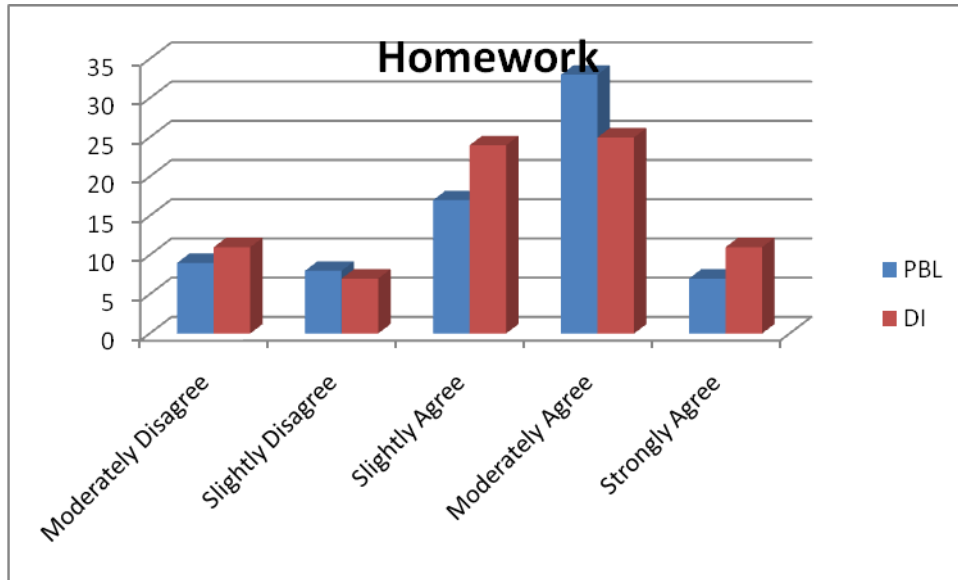


Figure 4

Based on Figure 4, one can see that the normal trend found with the previous three categories does not exist here. The DI responses are predominantly scattered throughout the option choices ranging from moderately agree, slightly agree, and strongly agree. Again, the normal trend found in the previous three categories included DI responses being the majority in the first three option choices and PBL responses being the majority in the last two option choices. This same trend is not depicted in Figure 4.

The following table marked as Table 11 depicts data from the chi-square test and the chi-square likelihood ratio test for the Homework Assignments category. Both p-values were found to be very close to or over 0.05.

Table 11

Chi-Square Test:		Chi-Square Likelihood Ratio Test:	
Chi-square (observed value)	3.351	Wilks' G ² (observed value)	3.366
Chi-square (critical value)	9.488	Wilks' G ² (critical value)	9.488
DF	4	DF	4
One-tailed p-value	0.501	One-tailed p-value	0.499
Alpha	0.05	Alpha	0.05

Raw data was collected from multiple sources which included a pre-test, post-test, and student questionnaire survey. Since two classes were used in the experiment, different student populations were diversified between the experimental and control group. The researcher believes that through this experimental methodology with random sampling that a triangulation of data did occur.

There is no formal qualitative data to share. This study only included formal quantitative data. However, informal qualitative observations were done by the researcher. These informal observations include watching students become more engaged and excited in the PBL class versus watching students become bored and passive in the DI class.

The following comments were overheard by the researcher while in the PBL class: “This is fun...”, “I like doing these investigations...”, and “We should do more of these...” The following comments were overheard by the researcher while in the DI class: “This is so boring...”, “This is a lot of notes to take...”, and “When is this class over?” Overall, it seemed that students enjoyed learning from these problem-based investigations in the PBL class and disliked the lecturing in the DI class.

A decrease in sample size for both the PBL class and DI class occurred because of a high rate of absenteeism during the post-test administration. The sample size of this study was slightly lower than originally planned due to these absences. The sample size for the PBL class decreased by fifteen percent for the pre-test and student questionnaire and decreased by twenty-five percent for the post-test. The sample size for the DI class decreased by eleven percent for the pre-test and student questionnaire and decreased by sixteen percent for the post-test. In addition, a fluctuation of instructional time from day to day between the PBL and DI class occurred, however, the overall amount of instructional time with both classes remained the same over the whole duration

of the study. Lastly, extra credit was given to both the PBL class and DI class dependent upon a raw cut score from the post-test to ensure students put effort and had incentive to complete the post-test.

Data Analysis

Two questions were asked prior to this study being conducted. The researcher wanted to know whether or not student achievement and attitude would be higher in a Problem-Based Learning environment versus a Direct Instructional environment.

Since there was no statistical differences in the participants pre-test scores, it was not necessary to conduct an analysis of covariance in order to determine if there was any differences in their post-test scores. Instead, a t-test was sufficient.

During an analysis of the post-test scores, a significant difference between mean raw scores was still present. Based on the student's one-tailed right-tailed t-test which assumed that the two theoretical variances are equal, and since the p-value was found to be under 0.05, the researcher is able to reject the null hypothesis of the equality of the means. Since the class that was taught using PBL had a higher mean raw score than the class being taught with DI, the researcher can also conclude that significant higher student achievement occurred in the PBL class and not the DI class. Based on the student's one-tailed right-tailed t-test using the Satterthwaite's method which assumed that the two theoretical variances were not equal, and since the p-value was found to be under 0.05, the researcher is able to reject the null hypothesis of the equality of the means and state that there is a significance of the mean raw scores. Since the class taught using PBL had a higher mean raw score than the class being taught with DI the researcher can again conclude that significant higher student achievement occurred in the PBL class and not the DI class with or without an assumption of variance.

An analysis of the central tendencies of the post-test raw score was conducted and the data shows significant student gains in achievement based on the experimental and control groups mean raw scores. With gains present, the researcher has reached a final conclusion that significantly higher student achievement occurred in a PBL classroom setting and not a DI classroom setting.

During an analysis of the student questionnaire survey responses, a significant difference in student attitude was present in three of the four categories. These three categories that portrayed significance in student attitude included Instructional Method, Activities, and Cooperative Learning Groups. Based on the chi-square test and chi-square likelihood ratio test both p-values were found to be under 0.05, therefore, the researcher is able to reject the null hypothesis that student attitude is not greater in a PBL classroom setting versus a DI classroom setting. The result of the chi-square test administered on the Homework category of the student questionnaire survey showed no significance in the data collected. This non-significant data is based on the fact that the p-value for the main chi-square test was found to be over 0.05. Because this p-value did not fall below the 0.05 mark the researcher is not able to reject the null hypothesis. Therefore, there is no conclusive quantitative evidence of an increase in student attitude toward homework assignments in either the PBL or DI classes.

The researcher believes that informal qualitative observations can explain for the disconnect between homework and student attitudes. The researcher is aware that the majority of students within the PBL and DI class do not enjoy having that extra burden of homework to complete. Also, many of these students have other obligations to tend to at home which can include watching younger siblings, doing household chores, completing other work and projects from other classes, and the most important factor, an abundance of distractions. These

distractions include perusing social networks such as Facebook, MySpace, and Twitter. Other distractions come from social communication tools such as AOL Instant Messenger, texting through the use of their cell phones, and posting replies on each other's walls (again, another Facebook tool!) Lastly, some of the students can be distracted from an abundance of other fun activities that they can do at home such as video games, hanging out with friends, or watching TV and movies. The student attitude toward homework may be viewed more as a barrier to having fun and relaxing at home. Hence, a disconnect between homework and student attitudes with PBL instruction.

Additional informal qualitative observations found higher engagement and excitement with students in the PBL class versus the students in the DI class. Students who were in the DI class seemed at times not in tuned to what the researcher was lecturing about on the board, whereas students in the PBL group seemed to enjoy the hands-on investigations being conducted in class. Also, the level of excitement of doing these hands-on activities seemed very high versus the underlying feeling of boredom that some students in the DI class exhibited while the researcher preached about the geometry topics and objectives of the day. Lastly, the comments overheard by the researcher further validate the perception of higher attitude in a PBL classroom setting versus a DI classroom setting.

An analysis of the comparison of responses between the PBL and DI class shows higher student attitude within a PBL classroom setting versus a DI classroom setting. A sixty-two percent majority of students in PBL chose options that favored an increase in attitude. A seventy-eight percent majority of students in DI chose options that did not favor an increase in attitude. Therefore, the researcher can conclude that an increase in student attitude toward the instructional method occurred in the PBL class and not the DI class. As an added bonus, the

researcher can also conclude that an increase in student attitude toward classroom activities and cooperative learning groups occurred in the PBL class and not the DI class.

Implications and Limitations

This experimental study can be used to further defend a progressive movement in the education industry which promotes more problem-based learning in high school classrooms and reduce the implementation of direct lecture-based instruction. It is quite possible for this research to be replicated in different high-school settings with different demographics which could further support or refute the conclusions the researcher has reached. For instance, it may be possible to show that in an urban school district PBL can be more or less effective because it focuses on the interests of that particular student body. Likewise, this study can be conducted in a community where the majority of families are near the poverty level to show that there may or may not be a level playing field for student achievement with or without family financial means.

A school community that is looking to implement more problem-based learning in their high school curriculum would find this study to be interesting. In addition, high school teachers, principals, and district superintendents who are also looking to install PBL at the high school level will find this study to be in support of the overall benefits of PBL versus DI which include higher student achievement and higher student attitude. Finally, the general community could find this research fascinating to the point that individual community members could lobby and demand an increase in PBL instruction at the high school level. Within about a five year time span, the researcher has noticed an increase in problem-based learning at the middle school level with the implementation of the Connected Math program. Overall, the parents in this particular community that the research was conducted in are familiar with PBL at the middle-school level, but know that PBL is almost non-existent at the high school level.

A few factors contributed to specific limitations during this study. One factor that the researcher encountered was an increase in absenteeism in both the experimental and control group. Many students found themselves stuck at home due to seasonal flu, H1N1 flu, and the common-cold.

Another factor was the limited amount of classes that could participate in this study. For convenience, the researcher chose the only two academic Geometry classes he taught. A larger sample size with multiple classes scattered between the experimental group and the control group would have contributed to a much larger sample size. This larger sample size could have increased the credibility of the conclusions made from this study. With this higher sample size, factors not related to pure PBL instruction that could influence and contaminate the data results of student achievement and attitude would have less of a chance of skewing the results, especially when students are randomly selected. Also, larger sample sizes ensure a diverse pool of participants where students prior knowledge, previous ability to problem solve, ability to keep social side conversations to a minimum, interest level, and focus would be scattered throughout the participant pool and have less of a chance of skewing the data results.

A third factor that the researcher decided to change during the study was the addition of extra credit depending on the raw score a student earned from the post-test. The researcher felt that some students would not take the post-test seriously if no credit was given for at least attempting the post-test. Therefore, a decision was made to give extra credit points which depended on a certain cut score earned on the post-test. In order to be fair and equitable, the extra credit was offered to both the experimental (PBL class) and control (DI class) group.

A fourth factor was the amount of class time between the PBL and DI class. This amount fluctuated due to NECAP testing for the junior class. In order to accommodate this rigid NECAP

testing schedule, some classes were shortened and other classes were lengthened. This did change the amount of time spent with the PBL and DI class from day to day, but based on the rotation of classes being shortened and lengthened, both the PBL and DI class had the same approximate amount of time with each given instructional method during the whole study.

Overall, the researcher found no additional problems in following the experimental design of this particular study. One change that could be made in the future would be to allow students access to the student questionnaire survey electronically. Since the student questionnaire survey was paper-based, the researcher had to input each survey into an Excel table to further analyze the data. An electronic survey would already have the survey results aggregated.

Critique

My career interests include conducting research and teaching at the university level or being a part of a think-tank research institution working for a government contract. I have recently applied to UMass Dartmouth as a doctoral candidate for their Mathematics Education PhD program. The competency-based education that I have gained from Western Governors University will truly contribute to my effectiveness as a mathematics teacher. Within this Master of Arts program in Mathematics Education I have learned research-based best-practices to implement in my classroom. I have gained confidence in my ability to complete graduate level coursework in math pedagogy and math content. Lastly, being able to complete this capstone gave me the research skills needed to perform additional research and prepare for a dissertation in the future.

A huge thank you goes to my mentor Gideon Weinstein who has inspired me to continue my studies and pushed me to realize my hopes and dreams. The additional phone calls also kept me on track on completing my studies early (sometimes a lot earlier when I knew that call was

going to happen each week). I felt the need to have at least something completed less I look like a procrastinating slacker who decided to take a one week vacation from it all. In addition, a big thank you goes out to Heather Dodds for introducing me to the little nuances of APA style writing. She was also able to review my prospectus with lightning speed efficiency and diligence which made me not miss my small window of opportunity for data collection, and to that I am very grateful! Lastly, I wish to thank my friends and relatives for cheering me on every step of the way.

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APPENDICES

Appendix A: Pre-Test and Post-Test

Pre-Test and Post-Test**Assessment Directions**

(Will be read by the teacher to the students and printed on Student Test Booklets)

You are now going to start the mathematics test. In this session, you will answer thirty-four multiple choice questions. You may not be able to answer every question, but it is important that you read each one carefully and do your best. If you are not sure of the answer to a question, you should make your best guess. Do not mark your answers in the Student Test Booklet. Instead, mark your answers on the given SCANTRON sheet. Choose the best answer for each multiple-choice question.

You may use your scratch paper to plan your answers and make notes, but only what you mark on your SCANTRON sheet will be scored. Please do not write on the Student Test Booklet. Your scratch paper will be collected at the end of the session. Does anyone have any questions?

You will be given eighty minutes to answer the questions in this session of the test. Please stop when you come to the stop sign at the end of the session. You may review your answers to the questions in this session of the test.

If you get stuck on a word in the test booklet, I can read the word to you. I cannot read numbers, mathematics symbols, or a whole question to you. If you want help reading a word, raise your hand. Are there any questions?

When you finish, insert your SCANTRON sheet and scratch paper into your Student Test Booklet. Please sit quietly and read until everyone is finished. You may begin.

***Teacher will circulate around the room to observe testing policies and procedures.

Triangle Unit Assessment

You are now going to start the mathematics test. In this session, you will answer thirty-four multiple choice questions. You may not be able to answer every question, but it is important that you read each one carefully and do your best. If you are not sure of the answer to a question, you should make your best guess. Do not mark your answers in the Student Test Booklet. Instead, mark your answers on the given SCANTRON sheet. Choose the best answer for each multiple-choice question.

You may use your scratch paper to plan your answers and make notes, but only what you mark on your SCANTRON sheet will be scored. Please do not write on the Student Test Booklet. Your scratch paper will be collected at the end of the session. Does anyone have any questions?

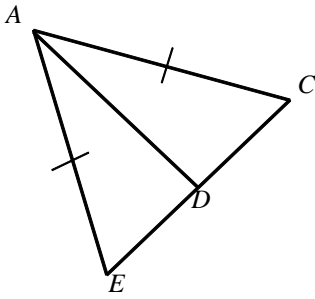
You will be given eighty minutes to answer the questions in this session of the test. Please stop when you come to the stop sign at the end of the session. You may review your answers to the questions in this session of the test.

If you get stuck on a word in the test booklet, I can read the word to you. I cannot read numbers, mathematics symbols, or a whole question to you. If you want help reading a word, raise your hand. Are there any questions?

When you finish, insert your SCANTRON sheet and scratch paper into your Student Test Booklet. Please sit quietly and read until everyone is finished. You may begin.

Student Test Booklet

1. Based on the marks in the diagram below, which sides can you assume congruent?



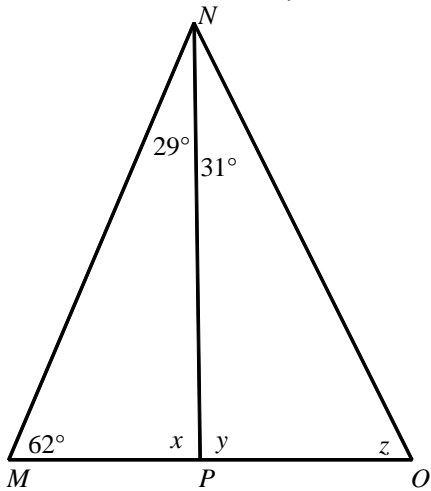
[A] $\overline{AE} \cong \overline{AC}$

[B] $\overline{CA} \cong \overline{CE}$

[C] $\overline{AE} \cong \overline{DC}$

[D] $\overline{CE} \cong \overline{AE}$

2. Find the values of x , y , and z .



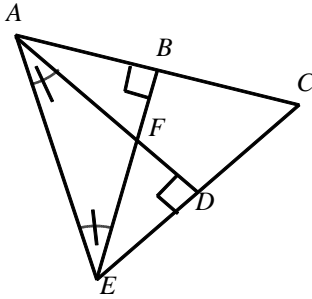
[A] $x = 89^\circ, y = 91^\circ, z = 60^\circ$

[B] $x = 89^\circ, y = 91^\circ, z = 58^\circ$

[C] $x = 91^\circ, y = 89^\circ, z = 60^\circ$

[D] $x = 91^\circ, y = 89^\circ, z = 58^\circ$

3. Determine which triangles in the figure are congruent by SAA.



[A] $\triangle AFE \cong \triangle EBC$

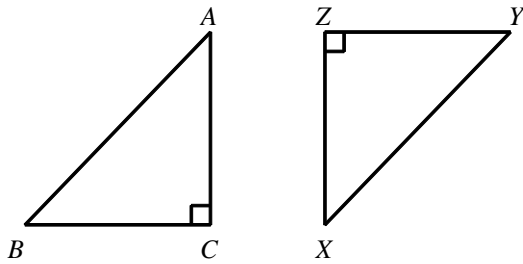
[B] $\triangle CEB \cong \triangle AEB$

[C] $\triangle ABF \cong \triangle EDF$

[D] $\triangle ABE \cong \triangle EDA$

4. Find the value of x so that $\triangle ABC \cong \triangle XYZ$.

$m\angle A = 46^\circ$, $BC = (7x + 3)$ meters, $m\angle X = 46^\circ$, $AC = 31$ meters, $YZ = (6x + 6)$ meters



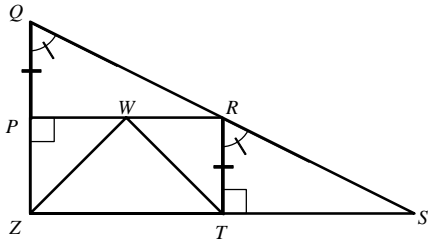
[A] $x = 6$

[B] $x = 5$

[C] $x = 3$

[D] $x = 4$

5. Refer to the figure below. Find a congruence statement for two triangles in the figure and name the congruence shortcut used.



[A] $\triangle WRT \cong \triangle WPZ$; SAA

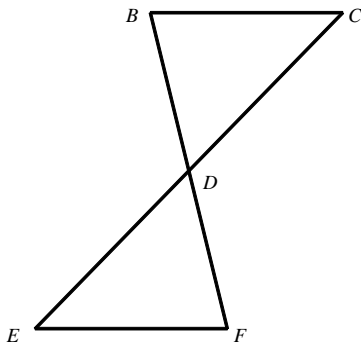
[B] $\triangle WRT \cong \triangle WPZ$; ASA

[C] $\triangle RPQ \cong \triangle STR$; SAA

[D] $\triangle RPQ \cong \triangle STR$; ASA

6. Refer to the figure shown. Which of the following statements is true?

$\overline{BC} \parallel \overline{EF}$, $BC = FE$



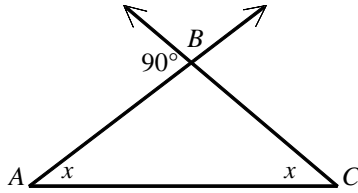
[A] $\triangle BCD \cong \triangle DFE$ by SAS

[B] $\triangle BCD \cong \triangle EFD$ by ASA

[C] $\triangle BCD \cong \triangle DFE$ by ASA

[D] $\triangle BCD \cong \triangle FED$ by ASA

7. Find the value of x .



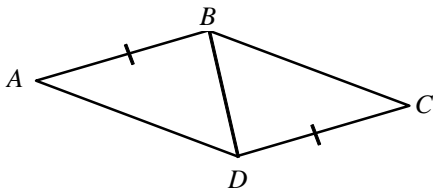
[A] 45°

[B] 90°

[C] 180°

[D] 88°

8. Determine what information you would need to know in order to use the SSS Congruence Conjecture to show that the triangles are congruent.



[A] $\angle BAD \cong \angle CDB$

[B] $\overline{AD} \cong \overline{BD}$

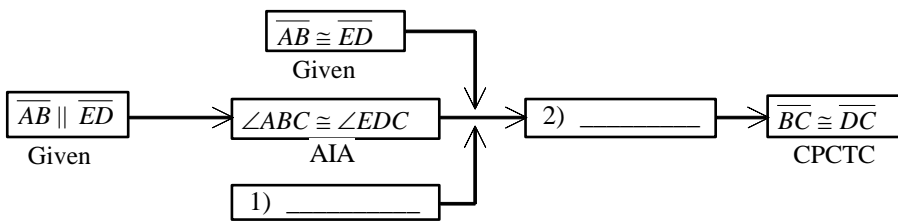
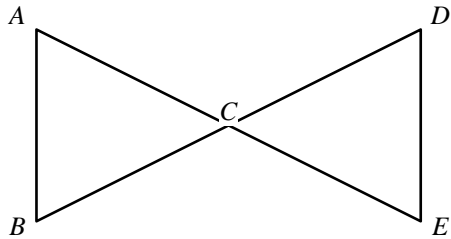
[C] $\angle ADB \cong \angle CBD$

[D] $\overline{AD} \cong \overline{CB}$

9. Which set of statements and reasons would correctly complete the flow chart proof?

Given: $\overline{AB} \cong \overline{ED}$
 $\overline{AB} \parallel \overline{ED}$

Show: $\overline{BC} \cong \overline{DC}$



[A] 1) $\angle ACB \cong \angle ECD$; VA Conj.

2) $\triangle ACB \cong \triangle ECD$; SAA

[B] 1) $\angle BAC \cong \angle EDC$; CA Conj.

2) $\triangle ACB \cong \triangle ECD$; ASA

[C] 1) $\angle ACB \cong \angle ECD$; VA Conj.

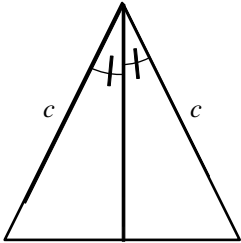
2) $\triangle ACB \cong \triangle ECD$; ASA

[D] 1) $\angle BAC \cong \angle EDC$; CA Conj.

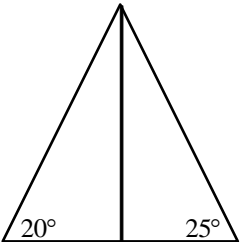
2) $\triangle ACB \cong \triangle ECD$; SAA

10. Which shows a median of a triangle?

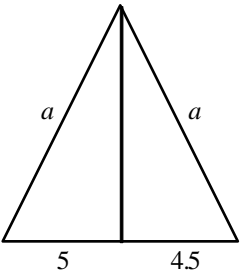
[A]



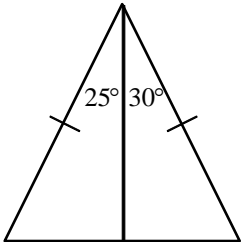
[B]



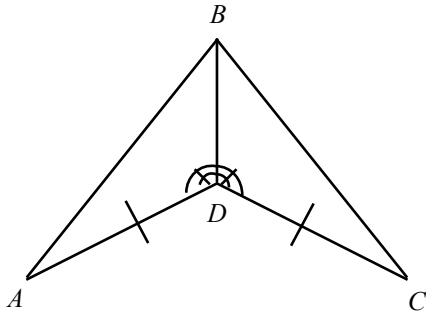
[C]



[D]



11. Use the markings on the diagram to determine why $\triangle ADB \cong \triangle CDB$. Choose the correct corresponding parts.



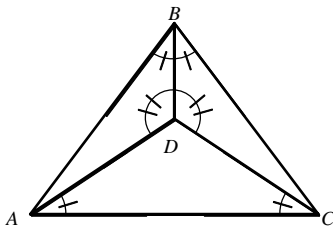
[A] SSS, $\angle A \cong \angle C$, $\angle ABD \cong \angle CBD$, $\angle ADB \cong \angle CDB$

[B] SSS, $\angle A \cong \angle C$, $\overline{AB} \cong \overline{CD}$, $\angle BDA \cong \angle DBC$

[C] ASA, $\angle A \cong \angle C$, $\overline{AB} \cong \overline{CB}$, $\overline{AD} \cong \overline{CD}$

[D] SAS, $\angle A \cong \angle C$, $\overline{AB} \cong \overline{CB}$, $\angle ABD \cong \angle CBD$

12. Determine which triangles in the figure are congruent by ASA.



[A] $\triangle ABD \cong \triangle ADC$

[B] $\triangle ABD \cong \triangle CBD$

[C] $\triangle CBD \cong \triangle ABC$

[D] $\triangle ABC \cong \triangle ADC$

13. Determine which three lengths can be measures of the sides of a triangle.

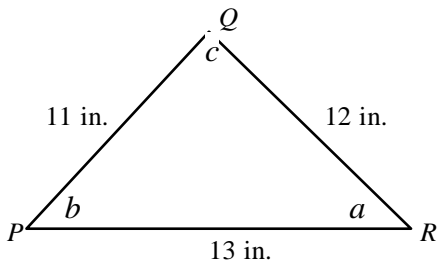
[A] 10 cm, 10 cm, 20 cm

[B] 5 cm, 13 cm, 20 cm

[C] 13 cm, 6 cm, 20 cm

[D] 10 cm, 11 cm, 20 cm

14. Arrange the unknown measures in order from greatest to least.



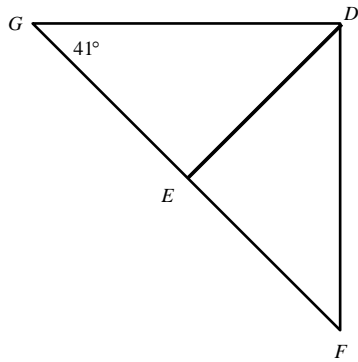
[A] b, c, a

[B] b, a, c

[C] c, b, a

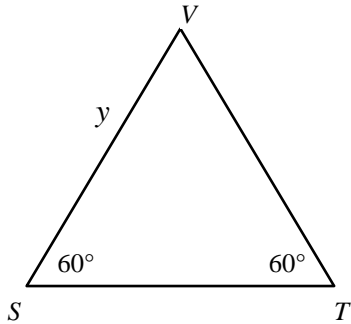
[D] c, a, b

15. \overline{DE} is a median and altitude of $\triangle GDF$. What is the measure of angle DFE ?



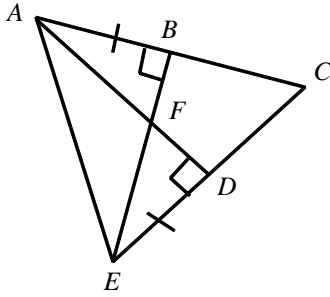
- [A] 41 degrees
- [B] 90 degrees
- [C] 39 degrees
- [D] 180 degrees

16. If the perimeter of $\triangle STV$ is 12 yards, what is the value of y ?



- [A] $y = 12$ yd
- [B] $y = 8$ yd
- [C] $y = 60$ yd
- [D] $y = 4$ yd

17. Determine which triangles in the figure are congruent by SAA.



[A] $\triangle ABF \cong \triangle EDF$

[B] $\triangle ADE \cong \triangle EBA$

[C] $\triangle ABF \cong \triangle AFE$

[D] $\triangle EFD \cong \triangle AFE$

18. If $\triangle ABC \cong \triangle DEF$, $AB = 11$ centimeters, $\angle ABC = 13^\circ$, and $\angle DFE = 25^\circ$, which of the following statements cannot be shown to be true?

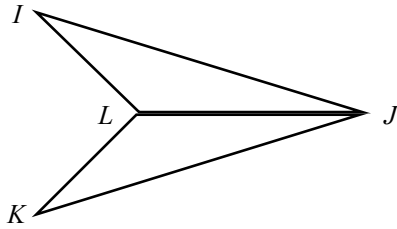
[A] $\angle CAB = 142^\circ$

[B] $FD = 11$ cm

[C] $\overline{BC} \cong \overline{EF}$

[D] $\angle D \cong \angle A$

19. In the figure below, \overline{LJ} bisects $\angle IJK$ and $\angle ILJ \cong \angle JLK$. Find a congruence statement for the two triangles in the figure and name the congruence shortcut used.



[A] $\triangle ILJ \cong \triangle K LJ$; ASA

[B] $\triangle ILJ \cong \triangle K LJ$; SAA

[C] $\triangle K LJ \cong \triangle LIJ$; SAA

[D] $\triangle K LJ \cong \triangle LIJ$; ASA

20. If $BCDE$ is congruent to $TUVW$, then \overline{CD} is congruent to which segment in $TUVW$?

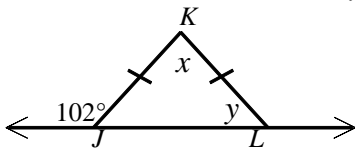
[A] \overline{UW}

[B] \overline{TW}

[C] \overline{UV}

[D] \overline{TU}

21. Find the values of x and y .



[A] $x = 78^\circ$; $y = 102^\circ$

[B] $x = 24^\circ$; $y = 78^\circ$

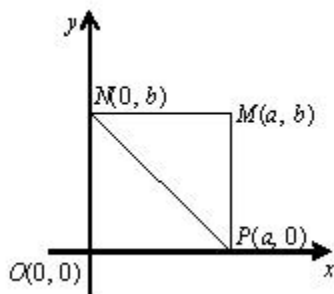
[C] $x = 78^\circ$; $y = 58^\circ$

[D] $x = 24^\circ$; $y = 102^\circ$

22. What is the measure of the vertex angle of an isosceles triangle if each base angle measures 38° ?

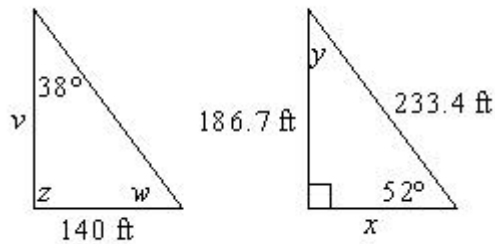
- [A] 19°
- [B] 76°
- [C] 104°
- [D] not enough information is given

23. You are given the coordinates of $\triangle NOP$ and $\triangle PMN$ shown below. You want to prove that $\triangle NOP \cong \triangle PMN$. Which of the reasons below would appear in your coordinate proof?



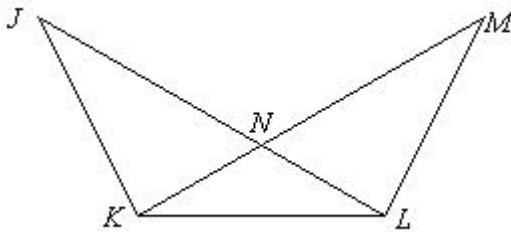
- [A] SSS Congruence Postulate
- [B] SAS Congruence Postulate
- [C] AAS Congruence Theorem
- [D] ASA Congruence Postulate

24. Two triangle-shaped lots are congruent. Find the missing side lengths and angle measures.



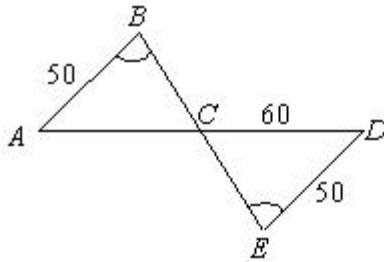
- [A] $v = 140$ ft; $w = 52^\circ$; $x = 186.7$ ft; $y = 38^\circ$; $z = 90^\circ$
 [B] $v = 233.4$ ft; $w = 90^\circ$; $x = 186.7$ ft; $y = 38^\circ$; $z = 38^\circ$
 [C] $v = 186.7$ ft; $w = 90^\circ$; $x = 140$ ft; $y = 38^\circ$; $z = 52^\circ$
 [D] $v = 186.7$ ft; $w = 52^\circ$; $x = 140$ ft; $y = 38^\circ$; $z = 90^\circ$

25. Given: $\angle JKL \cong \angle MLK$ and $\angle K LJ \cong \angle LKM$. What postulate or theorem can be used to show that $\triangle JKL \cong \triangle MLK$?

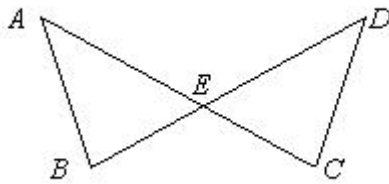


- [A] SAS
 [B] SSS
 [C] ASA
 [D] AAS

26. Which congruence postulate or theorem can be used to determine the measure of \overline{AC} ?



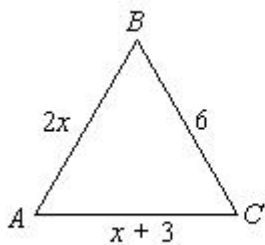
- [A] SSS
 [B] SAS
 [C] ASA
 [D] AAS
27. Refer to the figure shown. Give a congruence statement for the two triangles and name the theorem or postulate that proves the congruence.



$$AE = DE, BE = CE$$

- [A] $\triangle AEB \cong \triangle CED$ by SAS
 [B] $\triangle AEB \cong \triangle DEC$ by SAS
 [C] $\triangle AEB \cong \triangle DEC$ by SSS
 [D] $\triangle AEB \cong \triangle CED$ by SSS

28. Solve for x , given that $\overline{AB} \cong \overline{BC}$. Is $\triangle ABC$ equilateral?

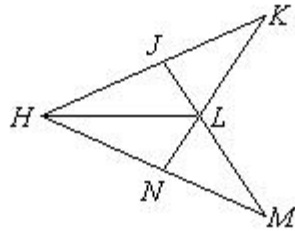


- [A] 3, yes
[B] 4, no
[C] 3, no
[D] 4, yes

29. What is the missing statement in the following proof?

Given: $\overline{HJ} \cong \overline{HN}$, \overline{HL} bisects $\angle JHN$

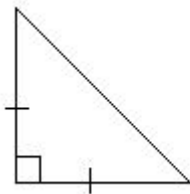
Prove: $\overline{JL} \cong \overline{NL}$



Statements	Reasons
1. $\overline{HJ} \cong \overline{HN}$, \overline{HL} bisects $\angle JHN$	1. Given
2. $\angle JHL \cong \angle NHL$	2. Definition of angle bisector
3. _____ ?	3. Reflexive Prop. of Congruence
4. $\triangle HJL \cong \triangle HNL$	4. SAS Congruence Postulate
5. $\overline{JL} \cong \overline{NL}$	5. \cong parts of \cong triangles are \cong

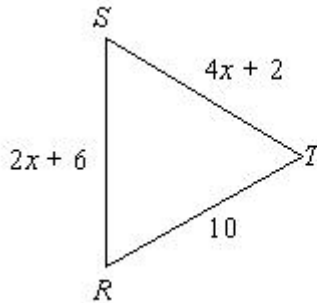
- [A] $\overline{HK} \cong \overline{HM}$
- [B] $\overline{HL} \cong \overline{HL}$
- [C] $\angle HJL \cong \angle HNL$
- [D] $\angle JHN \cong \angle JHN$

30. Classify the triangle by its angles and by its sides.



- [A] right scalene
- [B] obtuse isosceles
- [C] right isosceles
- [D] obtuse scalene

31. In $\triangle RST$, $\overline{RS} \cong \overline{TS}$. Which term does NOT describe the triangle?



- [A] equilateral
 [B] isosceles
 [C] acute
 [D] obtuse
32. In $\triangle XYZ$, if $\overline{XY} \cong \overline{YZ}$ and $m\angle X = 42^\circ$, then $m\angle Z =$ _____.
- [A] 69°
 [B] 42°
 [C] 138°
 [D] 21°
33. $\triangle ABC$ is equilateral. Which of the following statements is NOT true about $\triangle ABC$?
- [A] It is equiangular.
 [B] It is isosceles.
 [C] It has a right angle.
 [D] It has three congruent angles.
34. If $\triangle XYZ \cong \triangle ABC$, $XY = 4$ feet, $m\angle Y = 53^\circ$, and $m\angle C = 86^\circ$, which of the following statements is false?
- [A] $AB = 4$ feet
 [B] $m\angle B = 53^\circ$
 [C] $m\angle X = 86^\circ$
 [D] $YZ = BC$

DO NOT GO ON.



Appendix B: Student Attitude Survey

PORTSMOUTH HIGH SCHOOL | MR. MARUM'S GEOMETRY CLASS

Dear student:

Please fill out the following survey for homework and turn it into my INBOX next class. Place a checkmark in the box that you believe is the correct quality rating. Your feedback is completely anonymous. I truly appreciate your participation!

Student Survey	QUALITY RATING					
	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
INSTRUCTIONAL METHOD						
The instructional method used in the past two weeks was enjoyable.						
The instructional method used in the past two weeks enhanced my thinking skills.						
The instructional method used in the past two weeks will help me perform better on the NECAP assessment.						
The instructional method used in the past two weeks will help me perform better on future follow-ups and assessments in this class.						
The instructional method used in the past two weeks helped me learn new concepts.						
ACTIVITIES						
The activities used in the past two weeks were enjoyable.						
The activities used in the past two weeks enhanced my thinking skills.						
The activities used in the past two weeks will help me perform better on the NECAP assessment.						
The activities used in the past two weeks will help me perform better on future follow-ups and assessments in this class.						
The activities used in the past two weeks helped me learn new concepts.						

Student Survey	QUALITY RATING					
	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree

COOPERATIVE LEARNING GROUPS						
The cooperative learning groups used in the past two weeks were enjoyable.						
The cooperative learning groups used in the past two weeks enhanced my thinking skills.						
The cooperative learning groups used in the past two weeks will help me perform better on the NECAP assessment.						
The cooperative learning groups used in the past two weeks will help me perform better on future follow-ups and assessments in this class.						
The cooperative learning groups used in the past two weeks helped me learn new concepts.						

Student Survey	QUALITY RATING					
	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
HOMEWORK ASSIGNMENTS						
The homework assignments used in the past two weeks were enjoyable.						
The homework assignments used in the past two weeks enhanced my thinking skills.						
The homework assignments used in the past two weeks will help me perform better on the NECAP assessment.						
The homework assignments used in the past two weeks will help me perform better on future follow-ups and assessments in this class.						
The homework assignments used in the past two weeks helped me learn new concepts.						

Appendix C: Curricular Unit

LESSON PLAN**Name:** *Mr. Timothy Marum***WGU Task Objective Number:** *Capstone***GENERAL INFORMATION****Lesson Title & Subject(s):** *Introduction to Triangles (1-5) (PBL) (DI Modifications in RED)***Topic or Unit of Study:** *Triangle Properties***Grade/Level:** *10th Grade***Instructional Setting:** *Classroom, 20 students, arranged in 5 groups of 4 students per group, desks are arranged in a pin-wheel design to encourage group talk within cooperative learning groups (DI instructional setting includes students in five rows of four facing the front of the room)***Course Materials:** *Accessible online: Please go to www.mrmarum.com to view syllabus.***STANDARDS AND OBJECTIVES****Your State Core Curriculum/Student Achievement Standard(s):**

M(G&M)–10–2 Makes and defends conjectures, constructs geometric arguments, uses geometric properties, or uses theorems to solve problems involving angles, lines, polygons, circles, or right triangle ratios (sine, cosine, tangent) within mathematics or across disciplines or contexts (e.g., Pythagorean Theorem, Triangle Inequality Theorem). (State of Rhode Island)

Lesson Objective(s):

- *Learn how to interpret geometric diagrams*
- *Write definitions for types of triangles*

MATERIALS AND RESOURCES**Instructional Materials:**

*Discovering Geometry Book Third Edition, Key Curriculum Press 2003
(Accessible Online: www.keymath.com. Please use the word geometry as ClassPass)
Student Geometry Binder
Note-Taking Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Notetaking Guides. Use the word phs for both the username and password.)
Study Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Study Guides. Use the word phs for both the username and password.)
Homework Lesson Sheet (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click Homework Sheets. Use the word phs for both the username and password.)*

Resources:

N/A

INSTRUCTIONAL PLAN

Sequence of Instructional Procedures/Activities/Events (provide description and indicate approximate time for each):

1. Identification of Student Prerequisite Skills Needed for Lesson (5 min):

The purpose of this lesson is:

To have students be able to interpret geometric designs and write definitions for different kinds of triangles. Students then should be able to apply the knowledge gained to work on problems with a Depth of Knowledge of 1 and 2.

Skills Needed:

Students will have a solid background in creating appropriate definitions for geometric terms as seen in a previous lesson earlier in the school year called What's A Widget?

Definitions Needed:

Students have maintained a special section of their Geometry Notebook labeled "Definitions / Conjectures" and should have the following included: Right Triangle, Acute Triangle, Obtuse Triangle, Scalene Triangle, Equilateral Triangle, and Isosceles Triangle

Definitions of Terms Used In This Lesson Plan:

Right Triangle: A triangle with one right angle

Acute Triangle: A triangle with all angles that are less than ninety degrees

Obtuse Triangle: A triangle with one obtuse angle

Scale Triangle: A triangle where no sides are congruent

Equilateral Triangle: A triangle where all sides are congruent

Isosceles Triangle: A triangle with at least two sides that are congruent and a triangle with at least two angles that is congruent

2. Presentation of New Information or Modeling (30 min):

Students will be in heterogeneously mixed, mixed-ability, cooperative learning groups

Students will begin the following activity in their cooperative learning groups (direct instruction):

Teacher will lecture on the different types of triangles and have students write these definitions in their notebook.

Students will investigate different types of triangles by completing the Investigation within their cooperative learning groups found in their book on pg. 60-61.

Students will fill in questions that parallel with the questions asked on their Note-Taking Guide.

Teacher Questions:

What steps should you take in order to create a good geometric definition?

Student Questions:

What would be a good definition for this type of triangle?

3. Guided Practice (10 min):

Students will begin the following problems in their book pg. 64-65, #1-4, 10-12, 22-24, within their cooperative learning groups. These problems ask students what they can and cannot assume from a geometric diagram, matching geometric figures with the proper name, sketching and labeling different types of triangles, and coordinate geometry of different types of triangles.

Teacher will informally monitor students' progress and assist groups when needed

***The student's book edition is accessible online, www.keymath.com. Please see heading "Instructional Materials" from above for more information. ***

Teacher Questions:

None.

Student Questions:

None.

4. Independent Student Practice (35 min):

Students will re-arrange desks so that there are three rows of desks facing the window of the classroom.

Students will complete problems on the Study Guide that correspond to the learning objectives of the day. Students while working on the Study Guide will be classifying given types of triangles.

These problems consist of students applying all three conjectures from today's lesson.

***The Study Guide is accessible online, www.mrmarmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Prior to this lesson, students will have taken an assessment on geometric reasoning which includes the following topics: inductive reasoning, deductive reasoning, finding the n th term, and mathematical modeling. Normally students would take a Follow-Up Formative Assessment on the learning objectives of the prior class, but since an assessment was prior to this lesson, no follow-up will be assigned this class.

Teacher Questions:

None.

Student Questions:

None.

5. Culminating or Closing Procedure/Activity/Event (5 min):

Students are asked to create a Journal Entry when there are 5 minutes remaining in class. The journal prompt today is, "Explain in your own words how you created good geometric definitions this class."

HW Assigned: Lesson 1.5 #8, 10, 20-22, and 25

***The HW is accessible online, www.mrmarmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Pedagogical Strategy (or Strategies):

Students will be in cooperative groups to encourage group talk and teamwork.

The timing is good for an 85 minute block period.

Differentiated Instruction:

Individual differences are accommodated through extra guidance through work (especially those who need extra help with content knowledge by a special educator.)

Student Assessment/Rubrics:

Students will be informally graded on their participation during group investigations with a maximum of five possible points. Their Independent Student Practice assignment will be graded on effort with a maximum of ten possible points. Homework will be assigned and graded for effort on the following day with a maximum of four points.

Citations:

McGraw-Hill, (2007). *Geometry Skills Practice*. Glencoe.

McGraw-Hill, (2007). *Geometry Study Guide and Interventions*. Glencoe.

Serra, Michael (2003). *Discovering Geometry*. Key Curriculum Press.

Serra, Michael (2003). *Discovering Geometry Practice Workbook*. Key Curriculum Press.

LESSON PLAN

Name: Mr. Timothy Marum

WGU Task Objective Number: Capstone

GENERAL INFORMATION

Lesson Title & Subject(s): Triangle Sum Conjecture (4-1) (PBL) (DI Modifications in RED)

Topic or Unit of Study: Triangle Properties

Grade/Level: 10th Grade

Instructional Setting: Classroom, 20 students, arranged in 5 groups of 4 students per group, desks are arranged in a pin-wheel design to encourage group talk within cooperative learning groups (DI instructional setting includes students in five rows of four facing the front of the room)

Course Materials: Accessible online: Please go to www.mrmarum.com to view syllabus.

STANDARDS AND OBJECTIVES

Your State Core Curriculum/Student Achievement Standard(s):

M(G&M)–10–2 Makes and defends conjectures, constructs geometric arguments, uses geometric properties, or uses theorems to solve problems involving angles, lines, polygons, circles, or right triangle ratios (sine, cosine, tangent) within mathematics or across disciplines or contexts (e.g., Pythagorean Theorem, Triangle Inequality Theorem). (State of Rhode Island)

Lesson Objective(s):

- State a conjecture about the sum of the measures of the angles in a triangle
- Complete a paragraph proof of the Triangle Sum Conjecture
- State the Third Angle Conjecture

MATERIALS AND RESOURCES

Instructional Materials:

Discovering Geometry Book Third Edition, Key Curriculum Press 2003
(Accessible Online: www.keymath.com. Please use the word geometry as ClassPass)
Student Geometry Binder
Note-Taking Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Notetaking Guides. Use the word phs for both the username and password.)
Study Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Study Guides. Use the word phs for both the username and password.)
Homework Lesson Sheet (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click Homework Sheets. Use the word phs for both the username and password.)
Protractor
~~Straightedge~~

~~Scissors~~
~~Patty Paper~~
~~Colored Paper~~

Resources:

N/A

INSTRUCTIONAL PLAN

Sequence of Instructional Procedures/Activities/Events (provide description and indicate approximate time for each):

6. Identification of Student Prerequisite Skills Needed for Lesson (5 min):

The purpose of this lesson is:

To have students discover and develop the Triangle Sum Conjecture. Students will be able to discover and develop this conjecture through cooperative learning groups (direct instruction). Students then should be able to apply the knowledge gained to work on problems with a Depth of Knowledge of 1 and 2 independently.

Skills Needed:

Students will have already known basic triangle properties as discussed in the Introduction to Triangles in Section 1.5 of their textbook. These skills include identifying the exterior angle of a triangle and remote interior angles of a triangle.

Definitions Needed:

Students have maintained a special section of their Geometry Notebook labeled "Definitions / Conjectures" and should have the following included: Triangle Sum Conjecture, Third Angle Conjecture, Exterior Angle Theorem

Definitions of Terms Used In This Lesson Plan:

Triangle Sum Conjecture: The sum of the measures of the angles in every triangle is 180 degrees

Third Angle Conjecture: If two angles of one triangle are equal in measure of two angles of another triangle, then the third angle in each triangle is equal in measure to the third angle in the other triangle

Exterior Angle Theorem: The measure of an exterior angle of a triangle is equal to the sum of the measures of the two remote interior angles

7. Presentation of New Information or Modeling (30 min):

Students will be in heterogeneously mixed, mixed-ability, cooperative learning groups

Students will begin the following activity in their cooperative learning groups (direct instruction):

Teacher will take both conjectures listed in the following activity and have students write down the two conjectures in the notebook with the blanks filled in for them. In addition, teacher will lecture on how to do the Problem as described on the bottom of the Note-Taking Guide.



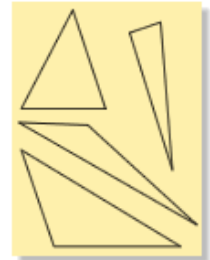
Investigation

The Triangle Sum

You will need

- a protractor
- a straightedge
- scissors
- patty paper

There are an endless variety of triangles that you can draw, with different shapes and angle measures. Do their angle measures have anything in common? Start by drawing different kinds of triangles. Make sure your group has at least one acute and one obtuse triangle.



- Step 1 Measure the three angles of each triangle as accurately as possible with your protractor.
- Step 2 Find the sum of the measures of the three angles in each triangle. Compare results with others in your group. Does everyone get about the same result? What is it?
- Step 3 Check the sum another way. Write the letters a , b , and c in the interiors of the three angles of one of the triangles, and carefully cut out the triangle.



- Step 4 Tear off the three angles.



- Step 5 Arrange the three angles so that their vertices meet at a point. How does this arrangement show the sum of the angle measures? Compare results with others in your group. State a conjecture.



Triangle Sum Conjecture

C-17

The sum of the measures of the angles in every triangle is $\underline{\quad ? \quad}$.

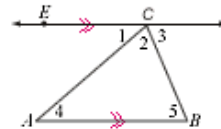
Steps 1 through 5 may have convinced you that the Triangle Sum Conjecture is true, but a proof will explain *why* it is true for every triangle.

- Step 6 | Copy and complete the paragraph proof below to explain the connection between the Parallel Lines Conjecture and the Triangle Sum Conjecture.

Paragraph Proof: The Triangle Sum Conjecture

To prove the Triangle Sum Conjecture, you need to show that the angle measures in a triangle add up to $?$. Start by drawing any $\triangle ABC$, and \overleftrightarrow{EC} parallel to side \overline{AB} .

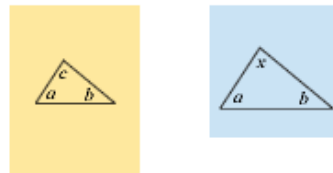
\overleftrightarrow{EC} is called an **auxiliary line**, because it is an extra line that helps with the proof.



In the figure, $m\angle 1 + m\angle 2 + m\angle 3 = 180^\circ$ if you consider $\angle 1 + \angle 2$ as one angle whose measure is $m\angle 1 + m\angle 2$, because $?$. You also know that $\overleftrightarrow{EC} \parallel \overline{AB}$, so $m\angle 1 = m\angle 4$ and $m\angle 3 = m\angle 5$, because $?$. So, by substituting for $m\angle 1$ and $m\angle 3$ in the first equation, you get $?$. Therefore, the measures of the angles in a triangle add up to $?$. ■

- Step 7 | Suppose two angles of one triangle have the same measures as two angles of another triangle. What can you conclude about the third pair of angles?

You can investigate Step 7 with patty paper. Draw a triangle on your paper. Create a second triangle on patty paper by tracing two of the angles of your original triangle, but make the side between your new angles a different length from the side between the angles you copied in the first triangle. How do the third angles in the two triangles compare?



- Step 8 | Check your results with other students. You should be ready for your next conjecture.

Third Angle Conjecture

C-18

If two angles of one triangle are equal in measure to two angles of another triangle, then the third angle in each triangle $?$.

Students will fill in questions that parallel with the questions asked on their Note-Taking Guide.

In addition, after students discover the Triangle Sum Conjecture on patty paper, students will complete the quick activity described on the Note-Taking Guide where they need to use construction paper to create the triangle, label angles, cut out the angles, and glue them in a specific way onto their Note-Taking Guide.

Also, students will include the proof of the triangle sum conjecture on their Note-Taking Guide. Finally, students will complete the Problem listed on the bottom of the Note-Taking Guide within their cooperative learning groups.

Teacher will present the Proof of the Triangle Sum Conjecture on the board to the students, and students will copy the proof into their notebooks.

***The Note-Taking Guide is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Book material screen shots have been provided for this investigation above. However, future lesson plans will make references to the book material which is accessible online, but the screen shots will be omitted. Only a description of the activity will be included.

Teacher Questions:

Why do we test obtuse AND acute triangles?

Why must we use a straightedge during our constructions?

Why must we be exact in our measurements of degree angles?

Student Questions:

How do I use the protractor?

What justification would I use in this part of the Proof of the Triangle Sum Conjecture?

8. Guided Practice (10 min):

Students will begin the following problems in their book pg. 201-202, #2-7, 8-9, within their cooperative learning groups. These problems ask students to find missing angles of a triangle using the triangle sum conjecture as well as other conjectures previously learned in the course.

Teacher will informally monitor students' progress and assist groups when needed

***The student's book edition is accessible online, www.keymath.com. Please see heading "Instructional Materials" from above for more information. ***

Teacher Questions:

What should all the angles of a triangle add up to?

Student Questions:

None.

9. Independent Student Practice (35 min):

Students will re-arrange desks so that there are three rows of desks facing the window of the classroom.

Students will complete problems on the Study Guide that correspond to the learning objectives of the day.

These problems consist of students applying the triangle sum conjecture and exterior angle theorem.

***The Study Guide is accessible online, www.mrmarmarum.com. Please see heading "Instructional Materials" from above for more information. ***

In addition to the problems from the Study Guide and Intervention worksheet which correspond to the learning objectives for today, students will also complete a Follow-Up Formative Assessment on the learning objectives from the previous class. These questions relate to class work and homework from the previous class. This assessment will be graded as described below under Student Assessments / Rubrics. Teacher will adapt future instructional practices dependent on the achievement that students exhibit on this formative assessment.

NAME _____ DATE _____ PERICO _____

4-1 Skills Practice

Classifying Triangles

Use a protractor to classify each triangle as *acute*, *equiangular*, *obtuse*, or *right*.

1.



2.



3.



4.



5.



6.

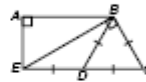


Lesson 4-1

Identify the indicated type of triangles.

7. right

8. isosceles



9. scalene

10. obtuse

ALGEBRA Find x and the measure of each side of the triangle.

11. $\triangle ABC$ is equilateral with $AB = 2x - 2$, $BC = 2x + 4$, and $CA = x + 10$.

12. $\triangle DEF$ is isosceles, $\angle D$ is the vertex angle, $DE = x + 7$, $DF = 3x - 1$, and $EF = 2x + 5$.

Find the measures of the sides of $\triangle RST$ and classify each triangle by its sides.

13. $R(0, 2)$, $S(2, 5)$, $T(4, 2)$

14. $R(1, 3)$, $S(4, 7)$, $T(5, 4)$

Teacher Questions:
None.

Student Questions:
None.

10. Culminating or Closing Procedure/Activity/Event (5 min):

Students are asked to create a Journal Entry and place it in their Journal Section of their notebook when there are 5 minutes remaining in class. The journal prompt today is, "Explain in your own words the process you undertook in proving the Triangle Sum Conjecture."

HW Assigned: Lesson 4.1

****The HW is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ****

Pedagogical Strategy (or Strategies):

Students will be in cooperative groups to encourage group talk and teamwork.

The timing is good for an 85 minute block period.

Differentiated Instruction:

Individual differences are accommodated through extra guidance through work (especially those who need extra help with content knowledge by a special educator.)

Student Assessment/Rubrics:

Students will be informally graded on their participation during group investigations with a maximum of five possible points. Their Independent Student Practice assignment will be graded on effort with a maximum of ten possible points. The follow-up will be graded out of a total of sixteen possible points. Homework will be assigned and graded for effort on the following day with a maximum of four points.

Citations:

McGraw-Hill, (2007). *Geometry Skills Practice*. Glencoe.

McGraw-Hill, (2007). *Geometry Study Guide and Interventions*. Glencoe.

Serra, Michael (2003). *Discovering Geometry*. Key Curriculum Press.

Serra, Michael (2003). *Discovering Geometry Practice Workbook*. Key Curriculum Press.

LESSON PLAN

Name: Mr. Timothy Marum

WGU Task Objective Number: Capstone

GENERAL INFORMATION

Lesson Title & Subject(s): *Properties of Special Triangles (4-2) (PBL) (DI Modifications in RED)*

Topic or Unit of Study: *Triangle Properties*

Grade/Level: *10th Grade*

Instructional Setting: *Classroom, 20 students, arranged in 5 groups of 4 students per group, desks are arranged in a pin-wheel design to encourage group talk within cooperative learning groups (DI instructional setting includes students in five rows of four facing the front of the room)*

Course Materials: *Accessible online: Please go to www.mrmarum.com to view syllabus.*

STANDARDS AND OBJECTIVES

Your State Core Curriculum/Student Achievement Standard(s):

M(G&M)–10–2 Makes and defends conjectures, constructs geometric arguments, uses geometric properties, or uses theorems to solve problems involving angles, lines, polygons, circles, or right triangle ratios (sine, cosine, tangent) within mathematics or across disciplines or contexts (e.g., Pythagorean Theorem, Triangle Inequality Theorem). (State of Rhode Island)

Lesson Objective(s):

- *Discover how the angles of an isosceles triangle are related*
- *Make a conjecture about Isosceles Triangles*
- *Apply the Isosceles Triangle Conjecture*

MATERIALS AND RESOURCES

Instructional Materials:

Discovering Geometry Book Third Edition, Key Curriculum Press 2003

(Accessible Online: www.keymath.com. Please use the word geometry as ClassPass)

Student Geometry Binder

Note-Taking Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Notetaking Guides. Use the word phs for both the username and password.)

Study Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Study Guides. Use the word phs for both the username and password.)

Homework Lesson Sheet (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click Homework Sheets. Use the word phs for both the username and password.)

Ruler (Straightedge)

Protractor

Patty Paper

Resources:

N/A

INSTRUCTIONAL PLAN

Sequence of Instructional Procedures/Activities/Events (provide description and indicate approximate time for each):

11. Identification of Student Prerequisite Skills Needed for Lesson (5 min):

The purpose of this lesson is:

To have students be able to make their own conjecture (have teacher lecture the conjecture) about the important properties of an Isosceles Triangle (i.e. that base angles are congruent) and apply the Isosceles Triangle Conjecture. Teacher will lecture the conjectures to the students. Students then should be able to apply the knowledge gained to work on problems with a Depth of Knowledge of 1, 2, and 3.

Skills Needed:

Students will need to brush up on algebra skills such as solving multi-step equations, combining like terms, and solving for a specific variable.

Definitions Needed:

Students have maintained a special section of their Geometry Notebook labeled “Definitions / Conjectures” and should have the following included: triangle, isosceles triangle, scalene triangle, equilateral triangle, equiangular triangle, congruent, acute triangle, obtuse triangle, Triangle Sum Conjecture, supplementary angles conjecture, linear pair conjecture, vertical angles conjecture, Side-Angle-Side Conjecture, Corresponding Parts of Congruent Triangles are Congruent Conjecture (CPCTC)

Definitions of Terms Used In This Lesson Plan:

Isosceles Triangle: A three-sided shape with at least two sides which are congruent

12. Presentation of New Information or Modeling (30 min):

Students will be in heterogeneously mixed, mixed-ability, cooperative learning groups

Students will begin the following activity in their cooperative learning groups (direct instruction):

Teacher will take conjectures listed in the following activity and have students write down the two conjectures in the notebook with the blanks filled in for them.

Students will investigate the Isosceles Triangle Conjecture and its Converse by completing both Investigation 1 and Investigation 2 within their cooperative learning groups found in their book on pg. 205 – 206.

Students will fill in questions that parallel with the questions asked on their Note-Taking Guide.

Teacher Questions:

What triangle have you created?

Explain how you know what kind of triangle it is?

What are the measures of the base angles?

How would you find angle congruencies with patty paper?

Could you fold patty paper to do this?

What can you say about the congruencies you found?

*What relationship do you notice between certain sides and angles?
How would you finish this conjecture: Isosceles Triangle Conjecture: "If a triangle is isosceles than..."*

Student Questions:

*What are the bottom angles of this triangle called?
Could you please help me with this step?*

13. Guided Practice (10 min):

Students will begin the following problems in their book pg. 206-207, #1-8, within their cooperative learning groups. These problems ask students to find missing angles of a triangle or complex diagram using the isosceles triangle conjecture as well as other conjectures previously learned in the course.

Teacher will informally monitor students' progress and assist groups when needed

****The student's book edition is accessible online, www.keymath.com. Please see heading "Instructional Materials" from above for more information. ****

Teacher Questions:

What is the significance of the base angles of an isosceles triangle?

Student Questions:

None.

14. Independent Student Practice (35 min):

Students will re-arrange desks so that there are three rows of desks facing the window of the classroom.

Students will complete problems on the Study Guide that correspond to the learning objectives of the day.

These problems consist of students applying the isosceles triangle conjecture.

****The Study Guide is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ****

In addition to the problems from the Study Guide and Intervention worksheet which correspond to the learning objectives for today, students will also complete a Follow-Up Formative Assessment on the learning objectives from the previous class. These questions relate to class work and homework from the previous class. This assessment will be graded as described below under Student Assessments / Rubrics. Teacher will adapt future instructional practices dependent on the achievement that students exhibit on this formative assessment.

NAME _____ DATE _____ PERIOD _____

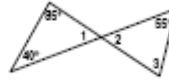
4-2 Skills Practice
Angles of Triangles

Find the missing angle measures.



Find the measure of each angle.

- 3. $m\angle 1$
- 4. $m\angle 2$
- 5. $m\angle 3$



Find the measure of each angle.

- 6. $m\angle 1$
- 7. $m\angle 2$
- 8. $m\angle 3$



Lesson 4-2

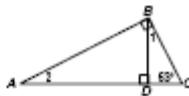
Find the measure of each angle.

- 9. $m\angle 1$
- 10. $m\angle 2$
- 11. $m\angle 3$
- 12. $m\angle 4$
- 13. $m\angle 5$



Find the measure of each angle.

- 14. $m\angle 1$
- 15. $m\angle 2$



Teacher Questions:

- What other conjectures do you have to use to solve these problems?
- Would the linear pair conjecture be helpful in this case?
- Would the vertical angle conjecture be helpful in this case?
- If all of these angles share the same line how many degrees are there total?

Student Questions:

- Would these angles be congruent?
- Would these sides be congruent?
- Would this be how I would set up the algebraic expression?
- What would be the next statement in this proof?

15. Culminating or Closing Procedure/Activity/Event (5 min):

Students are asked to create a Journal Entry when there are 5 minutes remaining in class. The journal prompt today is, "Explain why the isosceles triangle conjecture is significant. Create two problems using the Isosceles Triangle Conjecture and solve."

HW Assigned: Lesson 4.2

***The HW is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Pedagogical Strategy (or Strategies):

Students will be in cooperative groups to encourage group talk and teamwork.

The timing is good for an 85 minute block period.

Differentiated Instruction:

Individual differences are accommodated through extra guidance through work (especially those who need extra help with content knowledge by a special educator.)

Student Assessment/Rubrics:

Students will be informally graded on their participation during group investigations with a maximum of five possible points. Their Independent Student Practice assignment will be graded on effort with a maximum of ten possible points. The follow-up will be graded out of a total of sixteen possible points. Homework will be assigned and graded for effort on the following day with a maximum of four points.

Citations:

McGraw-Hill, (2007). *Geometry Skills Practice*. Glencoe.

McGraw-Hill, (2007). *Geometry Study Guide and Interventions*. Glencoe.

Serra, Michael (2003). *Discovering Geometry*. Key Curriculum Press.

Serra, Michael (2003). *Discovering Geometry Practice Workbook*. Key Curriculum Press.

LESSON PLAN

Name: Mr. Timothy Marum

WGU Task Objective Number: Capstone

GENERAL INFORMATION

Lesson Title & Subject(s): Triangle Inequalities (4-3) (PBL) *(DI Modifications in RED)*

Topic or Unit of Study: Triangle Properties

Grade/Level: 10th Grade

Instructional Setting: Classroom, 20 students, arranged in 5 groups of 4 students per group, desks are arranged in a pin-wheel design to encourage group talk within cooperative learning groups *(DI instructional setting includes students in five rows of four facing the front of the room)*

Course Materials: Accessible online: Please go to www.mrmarum.com to view syllabus.

STANDARDS AND OBJECTIVES

Your State Core Curriculum/Student Achievement Standard(s):

M(G&M)–10–2 Makes and defends conjectures, constructs geometric arguments, uses geometric properties, or uses theorems to solve problems involving angles, lines, polygons, circles, or right triangle ratios (sine, cosine, tangent) within mathematics or across disciplines or contexts (e.g., Pythagorean Theorem, Triangle Inequality Theorem). (State of Rhode Island)

Lesson Objective(s):

- Determine whether you can form a triangle from any three segments
- Discover a relationship between the side lengths and angle measures of a triangle
- Look for a relationship between the measure of the exterior angle of a triangle and the measures of the corresponding remote interior angles

MATERIALS AND RESOURCES

Instructional Materials:

*Discovering Geometry Book Third Edition, Key Curriculum Press 2003
(Accessible Online: www.keymath.com. Please use the word geometry as ClassPass)
Student Geometry Binder
Note-Taking Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Notetaking Guides. Use the word phs for both the username and password.)
Study Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Study Guides. Use the word phs for both the username and password.)
Homework Lesson Sheet (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click Homework Sheets. Use the word phs for both the username and password.)
Ruler (Straightedge)
Protractor
*Compass**

Resources:

N/A

INSTRUCTIONAL PLAN

Sequence of Instructional Procedures/Activities/Events (provide description and indicate approximate time for each):

16. Identification of Student Prerequisite Skills Needed for Lesson (5 min):

The purpose of this lesson is:

To have students be able to make their own conjecture (have teacher lecture the conjecture) about the learning objectives as mentioned above. Students then should be able to apply the knowledge gained to work on problems with a Depth of Knowledge of 1, 2, and 3.

Skills Needed:

Students will have a solid background of basic triangle properties from previous sections taught.

Definitions Needed:

Students have maintained a special section of their Geometry Notebook labeled “Definitions / Conjectures” and should have the following included: Triangle Inequality Conjecture, Side-Angle Inequality Conjecture, and Exterior Angles of a Triangle Conjecture

Definitions of Terms Used In This Lesson Plan:

Triangle Inequality Conjecture: The sum of the lengths of any two sides of a triangle is greater than the length of the third side.

Side-Angle Inequality Conjecture: In a triangle, if one side is longer than another side, then the angle opposite the longer side is larger than the angle opposite the shorter side.

Triangle Exterior Angle Conjecture: The measure of an exterior angle of a triangle is equal to the sum of the measures of the remote interior angles.

17. Presentation of New Information or Modeling (30 min):

Students will be in heterogeneously mixed, mixed-ability, cooperative learning groups

Students will begin the following activity in their cooperative learning groups (direct instruction):

Teacher will take conjectures listed in the following activity and have students write down the three conjectures in the notebook with the blanks filled in for them.

Students will investigate the Triangle Inequality Conjecture, the Side-Angle Inequality Conjecture, and the Triangle Exterior Angle Conjecture by completing Investigation 1 to 3 within their cooperative learning groups found in their book on pg. 214 – 216.

Students will fill in questions that parallel with the questions asked on their Note-Taking Guide.

Teacher Questions:

Are you able to construct a triangle with those given sides? Why or why not?

What is the significance of the sum of the measures of two sides of a triangle with the measure of the third side?

How do sides and angles of a triangle relate to one another?

Student Questions:

Could you please help me with this step?

18. Guided Practice (10 min):

Students will begin the following problems in their book pg. 216-217, #1-18, within their cooperative learning groups. These problems ask students if a triangle can be formed with the three given side measurements, ordering sides and angles of a triangle from least to greatest, and using a specific conjecture to find missing angles.

Teacher will informally monitor students' progress and assist groups when needed

***The student's book edition is accessible online, www.keymath.com. Please see heading "Instructional Materials" from above for more information. ***

Teacher Questions:

None.

Student Questions:

None.

19. Independent Student Practice (35 min):

Students will re-arrange desks so that there are three rows of desks facing the window of the classroom.

Students will complete problems on the Study Guide that correspond to the learning objectives of the day.

These problems consist of students applying all three conjectures from today's lesson.

***The Study Guide is accessible online, www.mrmarmarum.com. Please see heading "Instructional Materials" from above for more information. ***

In addition to the problems from the Study Guide and Intervention worksheet which correspond to the learning objectives for today, students will also complete a Follow-Up Formative Assessment on the learning objectives from the previous class. These questions relate to class work and homework from the previous class. This assessment will be graded as described below under Student Assessments / Rubrics. Teacher will adapt future instructional practices dependent on the achievement that students exhibit on this formative assessment.

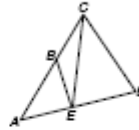


4-6 Skills Practice
Isosceles Triangles

NAME _____ DATE _____ PERIOD _____

Refer to the figure.

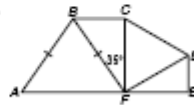
1. If $\overline{AC} \cong \overline{AD}$, name two congruent angles.
2. If $\overline{BE} \cong \overline{BC}$, name two congruent angles.
3. If $\angle EBA \cong \angle EAB$, name two congruent segments.
4. If $\angle CED \cong \angle CDE$, name two congruent segments.



Lesson 4-6

$\triangle ABF$ is isosceles, $\triangle CDF$ is equilateral, and $m\angle AFD = 150$. Find each measure.

- | | |
|------------------|------------------|
| 5. $m\angle CFD$ | 6. $m\angle AFB$ |
| 7. $m\angle ABF$ | 8. $m\angle A$ |



In the figure, $\overline{PL} \cong \overline{RL}$ and $\overline{LR} \cong \overline{BR}$.

9. If $m\angle RLP = 100$, find $m\angle BRL$.
10. If $m\angle LPR = 34$, find $m\angle B$.



Teacher Questions:

What other conjectures do you have to use to solve these problems?

Student Questions:

Would these angles be congruent?
Would these sides be congruent?

20. Culminating or Closing Procedure/Activity/Event (5 min):

Students are asked to create a Journal Entry when there are 5 minutes remaining in class. The journal prompt today is, "Explain why you cannot form some triangles with three given segments."

HW Assigned: Lesson 4.3

***The HW is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Pedagogical Strategy (or Strategies):

Students will be in cooperative groups to encourage group talk and teamwork.

The timing is good for an 85 minute block period.

Differentiated Instruction:

Individual differences are accommodated through extra guidance through work (especially those who need extra help with content knowledge by a special educator.)

Student Assessment/Rubrics:

Students will be informally graded on their participation during group investigations with a maximum of five possible points. Their Independent Student Practice assignment will be graded on effort with a maximum of ten possible points. The follow-up will be graded out of a

total of ten possible points. Homework will be assigned and graded for effort on the following day with a maximum of four points.

Citations:

McGraw-Hill, (2007). *Geometry Skills Practice*. Glencoe.

McGraw-Hill, (2007). *Geometry Study Guide and Interventions*. Glencoe.

Serra, Michael (2003). *Discovering Geometry*. Key Curriculum Press.

Serra, Michael (2003). *Discovering Geometry Practice Workbook*. Key Curriculum Press.

LESSON PLAN

Name: Mr. Timothy Marum

WGU Task Objective Number: Capstone

GENERAL INFORMATION

Lesson Title & Subject(s): Are There Congruence Shortcuts? (4-4 + 4-5) (PBL) (DI Modifications in RED)

Topic or Unit of Study: Triangle Properties

Grade/Level: 10th Grade

Instructional Setting: Classroom, 20 students, arranged in 5 groups of 4 students per group, desks are arranged in a pin-wheel design to encourage group talk within cooperative learning groups (DI instructional setting includes students in five rows of four facing the front of the room)

Course Materials: Accessible online: Please go to www.mrmarum.com to view syllabus.

STANDARDS AND OBJECTIVES

Your State Core Curriculum/Student Achievement Standard(s):

M(G&M)–10–2 Makes and defends conjectures, constructs geometric arguments, uses geometric properties, or uses theorems to solve problems involving angles, lines, polygons, circles, or right triangle ratios (sine, cosine, tangent) within mathematics or across disciplines or contexts (e.g., Pythagorean Theorem, Triangle Inequality Theorem). (State of Rhode Island)

Lesson Objective(s):

- Look for shortcuts for determining whether two triangles are congruent

MATERIALS AND RESOURCES

Instructional Materials:

*Discovering Geometry Book Third Edition, Key Curriculum Press 2003
(Accessible Online: www.keymath.com. Please use the word geometry as ClassPass)*
Student Geometry Binder
Note-Taking Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Notetaking Guides. Use the word phs for both the username and password.)
Study Guide (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click on Study Guides. Use the word phs for both the username and password.)
Homework Lesson Sheet (Accessible Online: www.mrmarum.com. Please view Geometry Materials on the menu bar and click Homework Sheets. Use the word phs for both the username and password.)
Ruler (Straightedge)
Protractor
Compass

Resources:

N/A

INSTRUCTIONAL PLAN

Sequence of Instructional Procedures/Activities/Events (provide description and indicate approximate time for each):

21. Identification of Student Prerequisite Skills Needed for Lesson (5 min):

The purpose of this lesson is:

To have students be able to make their own conjecture (have teacher lecture the conjecture) about the learning objectives as mentioned above. Students then should be able to apply the knowledge gained to work on problems with a Depth of Knowledge of 1, 2, and 3.

Skills Needed:

Students will have a solid background of basic triangle properties from previous sections taught.

Definitions Needed:

Students have maintained a special section of their Geometry Notebook labeled “Definitions / Conjectures” and should have the following included: SSS Congruence Shortcut, SAS Congruence Shortcut, ASA Congruence Shortcut, SAA Congruence Shortcut

Definitions of Terms Used In This Lesson Plan:

SSS Congruence Shortcut: If the three sides of one triangle are congruent to the three sides of another triangle, then the triangles are congruent

SAS Congruence Shortcut: If the two sides and the included angle of one triangle are congruent to two sides and the included angle of another triangle, then the triangles are congruent

ASA Congruence Shortcut: If two angles and the included side of one triangle are congruent to two angles and the included side of another triangle, then the triangles are congruent

SAA Congruence Shortcut: If two angles and a non-included side of one triangle are congruent to the corresponding angles and side of another triangle, then the triangles are congruent

22. Presentation of New Information or Modeling (30 min):

Students will be in heterogeneously mixed, mixed-ability, cooperative learning groups

Students will begin the following activity in their cooperative learning groups (direct instruction):

Teacher will take conjectures listed in the following activity and have students write down the three conjectures in the notebook with the blanks filled in for them.

Students will investigate the SSS Congruence Shortcut, SAS Congruence Shortcut, ASA Congruence Shortcut, and the SAA Congruence Shortcut by completing Investigation 1 and 2 within their cooperative learning groups found in their book on pg. 220 – 221 and by also completing the Investigation found on pg. 225-226.

Students will fill in questions that parallel with the questions asked on their Note-Taking Guide.

Finally, students will complete Example A and B found on their Note-Taking Guide and the teacher will circulate around the room by helping groups who have questions.

Teacher Questions:

Does this shortcut work? Why or why not?

Student Questions:

Could you please help me with this step?

23. Guided Practice (10 min):

Students will begin the following problems in their book pg. 222-223 #1-14 and pg. 227-228, #1-15, within their cooperative learning groups. These problems ask students to identify what parts of each triangle are congruent and ask if a conjecture shortcut can be used, why or why not.

Teacher will informally monitor students' progress and assist groups when needed

****The student's book edition is accessible online, www.keymath.com. Please see heading "Instructional Materials" from above for more information. ****

Teacher Questions:

None.

Student Questions:

None.

24. Independent Student Practice (35 min):

Students will re-arrange desks so that there are three rows of desks facing the window of the classroom.

Students will complete problems on the Study Guide that correspond to the learning objectives of the day.

These problems consist of students applying all three conjectures from today's lesson.

****The Study Guide is accessible online, www.mrmarmum.com. Please see heading "Instructional Materials" from above for more information. ****

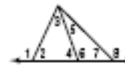
In addition to the problems from the Study Guide and Intervention worksheet which correspond to the learning objectives for today, students will also complete a Follow-Up Formative Assessment on the learning objectives from the previous class. These questions relate to class work and homework from the previous class. This assessment will be graded as described below under Student Assessments / Rubrics. Teacher will adapt future instructional practices dependent on the achievement that students exhibit on this formative assessment.

NAME _____ DATE _____ PERIOD _____

5-2 Skills Practice
Inequalities and Triangles

Determine which angle has the greatest measure.

- 1. $\angle 1, \angle 3, \angle 4$
- 2. $\angle 4, \angle 5, \angle 7$
- 3. $\angle 2, \angle 3, \angle 6$
- 4. $\angle 5, \angle 6, \angle 8$



Use the Exterior Angle Inequality Theorem to list all angles that satisfy the stated condition.

- 5. all angles whose measures are less than $m\angle 1$
- 6. all angles whose measures are less than $m\angle 9$
- 7. all angles whose measures are greater than $m\angle 5$
- 8. all angles whose measures are greater than $m\angle 8$



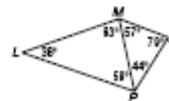
Determine the relationship between the measures of the given angles.

- 9. $m\angle ABD, m\angle BAD$
- 10. $m\angle ADB, m\angle BAD$
- 11. $m\angle BCD, m\angle CDB$
- 12. $m\angle CBD, m\angle CDB$



Determine the relationship between the lengths of the given sides.

- 13. $\overline{LM}, \overline{LP}$
- 14. $\overline{MP}, \overline{MN}$
- 15. $\overline{MN}, \overline{NP}$
- 16. $\overline{MP}, \overline{LP}$



Lesson 5-2

Teacher Questions:

What other conjectures do you have to use to solve these problems?

Student Questions:

Would these angles be congruent?

Would these sides be congruent?

25. Culminating or Closing Procedure/Activity/Event (5 min):

Students are asked to create a Journal Entry when there are 5 minutes remaining in class. The journal prompt today is, "Explain why a congruence shortcut Angle Angle Angle will not work."

HW Assigned: Lesson 4.4 and Lesson 4.5

***The HW is accessible online, www.mrmarum.com. Please see heading "Instructional Materials" from above for more information. ***

Pedagogical Strategy (or Strategies):

Students will be in cooperative groups to encourage group talk and teamwork.

The timing is good for an 85 minute block period.

Differentiated Instruction:

Individual differences are accommodated through extra guidance through work (especially those who need extra help with content knowledge by a special educator.)

Student Assessment/Rubrics:

Students will be informally graded on their participation during group investigations with a maximum of five possible points. Their Independent Student Practice assignment will be graded on effort with a maximum of ten possible points. The follow-up will be graded out of a total of ten possible points. Homework will be assigned and graded for effort on the following day with a maximum of four points.

Citations:

McGraw-Hill, (2007). *Geometry Skills Practice*. Glencoe.

McGraw-Hill, (2007). *Geometry Study Guide and Interventions*. Glencoe.

Serra, Michael (2003). *Discovering Geometry*. Key Curriculum Press.

Serra, Michael (2003). *Discovering Geometry Practice Workbook*. Key Curriculum Press.

Appendix D: Informed Consent Form

INFORMED CONSENT

Western Governors University

*Master of Arts in Mathematics Education**PBL vs. DI: Which Increases Student Achievement and Attitude?**Mr. Timothy Marum***Introduction:**

You are invited to participate in a research project being conducted by a researcher from Western Governors University. Mr. Timothy Marum is conducting research to determine which instructional method increases student achievement and attitude.

Description of the Project:

- *The purpose of this research is to determine whether Problem-Based Learning (PBL) or Direct Instruction (DI) increases student achievement and attitude*
- *The type of curriculum all students will participate in will either be problem-based or lecture-based with an introduction to many triangle properties*
- *The research will be conducted over a duration of seven block periods during your son's or daughter's Geometry class in mid-October*
- *All students are expected to participate fully in all routine classroom activities*
- *In addition to routine classroom activities each student participant will be required to complete a pre-test, post-test, and student survey*

Benefits and Risks of This Study:

Students will be exposed to research-based best-practices known to increase student achievement and attitude. Within the education industry, only a minute amount of research has been conducted on the effects of specific instructional methods that increase student achievement and attitude. This study will further increase research-driven practices to incorporate in a classroom setting. There are no known risks to participants who choose to be a part of this research study.

Confidentiality:

Participant confidentiality is of the utmost concern to the researcher. All participant's school records, written documents, and classroom assignments will be kept confidential. These school records, written documents, and classroom assignments will only be seen by the researcher. All of the data collected during this study will be aggregated and kept anonymous.

Voluntary Participation and Withdrawal:

All participants will be expected to participate in all regular classroom instruction but may choose to voluntarily participate or withdraw from photo capturing and videotaping. Since tests and surveys are used to inform instruction and measure student gains, these are considered part of regular classroom activities.

All participants may withdraw at any time from non-regular classroom instruction and will not be penalized for non-participation. These voluntary activities include photo capturing and videotaping. Participants can agree to participate in these voluntary activities or opt-out.

Questions, Rights, and Complaints:

You may contact the researcher of this study with any questions, comments, or concerns. The following includes the contact information of the researcher:

*Mr. Timothy Marum
401-683-2124
marumt@portsmouthschoolsri.org*

All participants and legal guardians have a right to view the results of this study.

CONSENT STATEMENT:

BY SIGNING THIS INFORMED CONSENT FORM BOTH THE STUDENT PARTICIPANT AND LEGAL GUARDIAN AGREES TO PARTICIPATE IN THIS RESEARCH STUDY.

Signature of Participant

Signature of Legal Guardian

Typed/printed Name

Typed/printed Name

Date

Date