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Differentiated Instruction in the New York State Geometry Curriculum

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Differentiated Instruction in the New York State Geometry Curriculum

by

Vicki S. Newman

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# Table of Contents

**Chapter 1: Introduction** ......................................................... 3  
  Problem Statement .............................................................. 4  
  Purpose .................................................................................... 4  
  Rationale .................................................................................. 5  

**Chapter 2: Literature Review** ................................................. 6  
  Concept Based Curriculum and Instruction .................................. 6  
  Differentiated Instruction ........................................................ 7  
  Instructional Strategies that Support Differentiated Instruction ....... 9  
  Grading and Assessment .......................................................... 11  
  Differentiated Instruction & Understanding by Design .................. 14  
  Research on Differentiated Instruction ....................................... 16  

**Chapter 3: Application** .......................................................... 17  
  Desired Results ......................................................................... 18  
  Assessment Evidence .................................................................. 20  
  Learning Plan ............................................................................ 24  

**Chapter 4: Data Analysis** ........................................................ 27  
  Survey Data ................................................................................ 27  
  *Table 1: Learning Mathematics Survey Results Before Differentiated Instruction* .............................................. 28  
  *Table 2: Learning Mathematics Survey Results After Differentiation Instruction* ............................................. 29  
  *Table 3: Question Response Values* ......................................... 30  
  Analysis ..................................................................................... 30  
  *Table 4: Student Responses Before Differentiated Instruction* ................................................................. 31  
  *Table 5: Student Responses After Differentiated Instruction* ................................................................. 31  
  *Table 6: Survey Question’s t-statistics* ................................. 32  

**Chapter 5: Conclusions** ............................................................ 32  

**Chapter 6: Recommendations** .................................................. 36  

**References** ............................................................................... 39  

**Appendix** ................................................................................ 41  
  Survey Questions ....................................................................... 42  
  Student Responses to Survey Questions 9 and 10 Before Differentiation ................................................................. 43  
  Student Responses to Survey Questions 9 and 10 After Differentiation ................................................................. 45  
  Figure 1: Identify Angle Pairs Practice (Front) ............................ 47  
  Figure 2: Identify Angle Pairs Practice (Back) ............................ 48  
  Figure 3: Investigating Angles and Parallel & Non-Parallel Lines  49
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INTRODUCTION

Teaching and learning have changed significantly over the past fifty years. The traditional styles of lecture and practice still exist but are not as abundant as they once were. This is due to the fact that research is showing students are not all the same; they do not learn the same, or think the same.

In the classic novel To Kill a Mockingbird by Harper Lee, Jean Louise Finch (Scout) gets into trouble with her teacher Miss Caroline on the first day of school. Scout describes her encounter:

"As I read the alphabet a faint line appeared between her eyebrows, and after making me read most of My First Reader and the stock-market quotations from The Mobile Register aloud, she discovered that I was literate and looked at me with more than faint distaste. Miss Caroline told me to tell my father not to teach me any more, it would interfere with my reading" (Lee,1960, 21).

Miss Caroline was frustrated that Scout was already literate and reading at a much higher level than any student in her grade. Miss Caroline expected all of her students to be at the same level in all aspects, and was discouraged to find that her students' abilities were quite different. Today's classrooms are still heterogeneous; they contain students from different backgrounds, socioeconomic statuses, cultures, ability levels, and life experiences. Instead of ignoring or stifling these differences, teachers need to adjust their instruction to meet the needs of the learners in their classrooms. Some students need accommodations or modifications made to the instruction to meet their needs, and others need to be challenged beyond what is being presented in the classroom. Studies have shown that heterogeneous classrooms are effective socially and academically; but have not proven that the needs of all learners being met. In a typical classroom, the
teacher instructs to the middle, or the average student, not to the student with special needs or those who are gifted. This frustrates the students who are functioning below grade level and bores students who are considered above average. This traditional way of teaching to the average student is not fair to students who do not fit in to that particular mold.

Problem Statement

Mathematics is an especially difficult subject for many students because what they are taught in school is skills-based and is constantly building on prior knowledge. If students do not learn a particular skill for a unit, then they will not be able to complete the more difficult tasks/questions that synthesize many skills later in that unit. This is also true for skills used throughout a course and in consecutive grades. Differentiated instruction can be a useful tool for teaching mathematics because it is designed to assess students and then adjust instruction to fit their needs. Experts theorize that differentiated instruction is effective, but does it improve student learning? Many teachers, administrators, parents and students would like to know whether teaching with differentiation is effective. Teachers and administrators want to provide the best learning experience for students, as it is their professional responsibility and ultimate goal. Parents want to know that their children are receiving a high quality education with the best instructional methods, and students want to know that they are receiving the best education from the most qualified teachers.

Purpose

In order to demonstrate that differentiated instruction can be used in the mathematics classroom I have designed the following curriculum project. In this project
I used a variety of differentiated instruction techniques in my daily teaching of a geometry concept based course. The purpose of this project was to create a unit plan based on a state and school concept based curriculum that uses differentiated instruction techniques to enhance student learning and interest while meeting each student's individual needs. The curriculum project includes the unit plan with content standards, learning activities, and assessments.

I also designed a survey for students to complete before and after the differentiated unit was taught. Students answered ten questions on an anonymous online survey. The questions are intended to show students attitudes toward instruction and activities in class, as well as their opinions of their own learning throughout the unit. My intent is to show that using differentiated instruction in the mathematics classroom will improve student motivation and student learning.

**Rationale**

This project is an important and significant contribution to the research and development of differentiated instruction because it is written for a New York State mathematics curriculum. Many teachers don’t believe that differentiation in their classrooms is possible because of the state standards and standardized tests at the end of the school year. This is especially true of mathematics teachers due to the fact that the New York State Mathematics curriculums are rigorous, demanding and packed with information. It is important that current mathematics teachers and students who are in mathematics teacher programs have an example of a curriculum that was designed for differentiated instruction with a unit plan containing differentiated tasks as well as examples of proper use of formative assessments in the classroom.
LITERATURE REVIEW

Concept Based Curriculum and Instruction

Throughout the country standards are being raised, students are being pushed harder, and teachers are asked to fit more content into their already packed curricula. The amount of material that each teacher must teach their students is unreasonable. In order for students to completely understand a topic or idea they need to move beyond just the facts or declarative knowledge. State curricula are designed to push in more material, creating several difficulties for teachers. Teachers are trying to cover the material, but the students are not actually learning. Since we know that changing the curriculum to include fewer standards will never happen, there must be a more effective way to teach students for understanding rather than rote memorization.

Concept based curricula and instruction focus instruction around a central theme or concept. It incorporates a "conceptual lens." "A conceptual lens forces students to think through and beyond the facts to consider transferable lessons— the generalizations that highlight patterns and connections" (Erickson, 2001, 22). Concepts are the foundations of a discipline; they organize ideas and connect topics and generalizations. A concept is abstract, timeless, and can be applied to many disciplines. For history concepts are easy to identify, like conflict or change. Almost any time period or event in history had some type of conflict or endured a change (Erickson, 2001). Once a teacher has established what concepts are important for students to learn, they can begin to organize the topics they need to teach that fit that concept, and what facts are important to include when teaching those topics. This way of thinking and teaching allows
teachers and students to draw more connections between topics and creates a more cohesive curriculum (Erickson, 2000).

Using a concept based curriculum allows teachers the freedom to teach without following a textbook. Once the concepts, topics and important facts are established, it is up to the teacher to present the material in a way that is appropriate for their students. Teachers can then base their lessons on the major concepts as opposed to just the facts. This permits teachers the opportunity to design lessons to meet the needs of all students. Using a curriculum designed to teach concepts is easily differentiated. In order to differentiate instruction in a concept based course, lessons can be centered on the same concept but the teacher can use student interest, readiness or learning style to create a variety of learning activities for their students. These learning activities achieve the same goal, but in different ways ensuring that students learning in the way that is best for them.

**Differentiated Instruction**

Differentiated instruction is not a new idea in the field of education; it incorporates many different educational theories and practices. Carol Ann Tomlinson defines differentiated instruction as a teacher's response to learner's needs by differentiating content, process, and product according to a student's readiness, interests, and learning profile (Tomlinson & Allan, 2000, 3). Differentiation by student readiness is based on brain research that shows that people learn things only when their brain is developed enough and is "ready" to do so. Psychologist Lev Vygotsky conducted research on learner readiness; he found that if a student can function independently without any assistance or is overwhelmed with a task and cannot complete it at all, then
the student is not learning. However, if a task is just outside of a student’s comfort level and the student can complete it with support from an adult, then the student will learn. “The area in which a child cannot successfully function alone but can succeed with adult scaffolding or support is that child’s zone of proximal development” (Tomlinson & Allan, 2000, 19). Therefore, we must coach students in tasks that are just beyond their masterly level and push them out of their comfort zone in order to have any learning success. A learner’s success is important for their attitudes, self perceptions and motivation to learn.

Motivating students to learn is a difficult task for many content areas. One way to motivate students is to use their interests. If students are interested in something, learning becomes a priority. When students are interested in learning it also increases creativity, curiosity and persistence. Csikzentmihalyi and Csikzentmihalyi developed a “theory of flow” which is “a state of total absorption that comes from being lost in an activity that is so satisfying that the participant loses tract of time, weariness, and everything else but the activity itself” (Tomlinson & Allan, 2000, 20). I compare this to athletes during a game or meet; they become so involved in what is going on in their game and their own motivation to win that they do not hear the cheers of the crowd around them. If we could tap into students’ interests like this, our classrooms would be more productive and students would be more focused. I understand that there is not always a way to make learning every topic so intensely motivating because all students are interested in different things and learn in different ways, but teachers should be striving to interest all students during all lessons.
Students learn in a variety of different ways. They each have their own “learning profile” which includes learning style, grouping preference and environmental preference (Bailey & Williams-Black, 2008). Two very well-known intelligence theorists, Howard Gardner and Robert Sternberg, both propose their own theory of multiple intelligences. “Gardner proposes eight potential intelligences: verbal-linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal, and naturalist” (Tomlinson & Allan, 2000, 21). Whereas, Sternberg proposes only three intelligences: analytical, creative and practical. However, the two theories believe that “intelligence is a capacity to solve problems or produce products valued by the society in which an individual lives” (Tomlinson & Allan, 2000, 21). There have been numerous studies based on the work of Gardner and Sternberg and many have found that using multiple intelligences can improve student learning and success. “Even by partially matching instruction to (learning patterns), we could improve student achievement” (Tomlinson & Allan, 2000, 28).

**Instructional Strategies that Support Differentiated Instruction**

There are many different ways to differentiate instruction in the classroom. Carol Ann Tomlinson explains in *The Differentiated Classroom: Responding to the Needs of All Learners* that teachers can differentiate content, process or product based on student’s readiness, interests or learning profiles (Tomlinson, 1999, 15). Some instructional strategies that support this include stations, agendas, complex instruction, orbital studies, centers, entry/exit cards, tiered activities and learning contracts. Teachers have to choose what strategies best fit their students and the material being taught (Tomlinson, 1999, 66).
Agendas are a strategy that outlines for students exactly what they need to do, and when it should be completed. “An agenda is a personalized list of tasks that a particular student must complete in a specified time. Student agendas throughout a class will have similar and dissimilar elements on them” (Tomlinson, 1999, 66). Agendas provide structure for students and a clear attainable goal. Students of all ages appreciate a clear guide for what they need to accomplish, and feel successful when they begin checking items off their list. Another strategy that Tomlinson describes in her book The Differentiated Classroom: Responding to the Needs of All Learners is stations. Stations allow students to work on different tasks at different times in different parts of the room.

“Not all students need to spend the same amount of time in each station. Further, even when all students do go to every station, assignments at each station can vary from day to day based on who will rotate there” (Tomlinson, 1999, 62). At the secondary level, stations could focus on different topics with each station having tiered lessons/activities provided for the students who rotate there. The tiered activities provide an opportunity for students to engage in practice that is respectful of their learning needs.

Tiered activities are an excellent strategy for differentiating content based on either student readiness or interest. Teachers can assign students to a specific tier or let them choose on their own. Carol Ann Tomlinson explains that these activities are designed so that

“All students focus on essential understanding and skills but at different levels of complexity, abstractness, and open-endedness. By keeping the focus of the activity the same, but providing routes of access at varying degrees of difficulty, the teacher maximizes the likelihood that each student comes away with pivotal skills and understanding and that each student is appropriately challenged” (Tomlinson, 1999, 83).
Tiered activities keep students working in what Vygotsky called the Zone of Proximal Development. In his article *When Students Choose the Challenge*, David Suarez describes how well his students responded to tiered activities where they chose their own challenge level. “Gabi, who tends to select green level (foundational) assignments, commented, ‘I like having choice because you decide whether you are ready for a harder challenge or not.’ When I asked Johannes how he was feeling about an upcoming black-level test, he replied ‘Excited!’” (Suarez, 2007, 63). Allowing student’s the freedom of choice tends to be a motivating factor, especially in younger students. However, using an assessment to assign students to a particular tier/level is equally beneficial. Formative assessments are great tools for tracking student progress and addressing their difficulties. Differentiating in this manner is similar to what coaches do for their athletes; they observe a player’s weakness and then make them practice until it improves. David Suarez also found that his students were performing better and at a higher level than previous years. “Our teachers implementing tiered math instruction have been extremely pleased with the results so far. Students are performing at higher levels of achievement, are more motivated and are assuming more responsibility for their learning” (Suarez, 2007, 62).

**Grading and Assessment**

The only way to measure what students have learned is to assess them in some form. Generally, teachers can only assign a numeric grade or an effort grade for each student. Our nation is very focused on summative assessments such as national achievement tests, state exams and district wide testing. These types of assessment teach students to memorize and encourage teachers to teach to the test, not for student understanding. President George W. Bush signed a law that requires standardized
testing of every student in the United States in reading and mathematics each year for third through eighth grade (Stiggins, 2002, 2). All of the standardized testing that takes place in our country shows that we assess learning as a result, not as process or opportunity for new learning.

The country's focus on standardized testing has created classrooms that also focus on summative assessments. Teacher's test at the end of a unit, they grade the test, return it to students and never speak of it again. Thinking of assessment as a process or as an opportunity for new learning would be more beneficial to students. These types of assessments allow students to see their strengths and weaknesses and a chance to reconcile any misunderstandings they may have. "When it is done properly, teachers use the classroom-assessment process and the continuous flow of information about student achievement to advance, not merely check on, student progress" (Stiggins, 2002, 2).

This flow of information allows the teacher to adjust instruction based on the results of assessments and the immediate needs of the students. Allowing students to build their knowledge in this way also gives them an opportunity to build confidence in the abilities to learn and be persistent, as opposed to become frustrated or give up (Stiggins, 2002).

Research indicates that formative assessment raises standards. "Studies show that innovations that include strengthening the practice of formative assessment produce significant and often substantial learning gains" (Black & Williams, 1998, 3). Studies also indicate that there is a more significant improvement for low achieving students than high achieving students, thus bridging the gap between the two groups (Black & Williams, 1998, 3). This idea alone, that we can help our weakest students and close the learning gap, should be argument enough for the effectiveness of formative assessment.
Looking at the Third International Mathematics and Science Study (TIMSS) results, if the United States had used more formative assessment, we could have placed in the top five nations as opposed to 21st out of 41 (Stiggins, 2002, 5). This is a phenomenal claim, and is supported by research. The impact of formative assessment is so powerful; there is no other tool so small and powerful.

The idea of formative assessment is that students are assessed on new learning, and then given an opportunity to fill in their gaps. With this in mind, we must assess students frequently, adjust our instruction to meet their needs, and then provide another assessment opportunity. Not all assessments need to be formal; they can be informal and formative checks for understanding. A formative assessment such as an entry/exit card should not be graded but used to diagnose student strengths and weaknesses. The information gained from a formative assessment can “help the teacher evaluate the effectiveness of a lesson design and keep instruction focused on key learning goals and individual needs” (Brimijoin, 2003, 71). Teachers can also use student self-assessments. Kay Brimijoin in her article Using Data to Differentiate Instruction, describes how one fifth grade teacher, Ms. Martez uses self assessment in her classroom. “How many [of you] are clear as glass about how greatest common factor works? How many have bugs on your windshield? How many have windshields covered with mud?” (Brimijoin, 2003, 70). Most of the time, the student’s self-assessments are in line with Ms. Martez’s formative assessments. Students who are “clear as glass” understand and can apply the skills and concepts; they are able to complete a challenge activity. Students who are “buggy” understand the basic concepts and skills; they are able to complete grade level work. Students who are “muddy” are having a difficult time with concepts and skills and need
remedial practice or instruction before moving on. Without this type of formative assessment, Ms. Martez would just move on and teach to the middle of the class.

Formative assessment is what guides differentiated instruction. Carol Ann Tomlinson explains that “consistent meaningful feedback clarifies for students present successes and next learning steps. Using such methods as student self-assessments based on pre-established criteria…may be more helpful than assigning a letter or number grade” (Tomlinson, 2001, 14). She also explains that “figuring out where they are in knowledge, understanding, and skill and moving them on from there” is the most effective way to teach (Tomlinson, 2001, 12). In an ideal world, each student could be given a grade based on their growth from pre-assessment, through formative assessments and then the summative assessment. However, we live in a culture of people who expect numeric grades or effort grades in order to measure success.

**Differentiated Instruction & Understanding by Design**

Understanding by Design is a curriculum design that focuses on teaching for understanding. It uses a backward design in which educators look at the goals, and then determine how to help students reach those goals. The design incorporates performance standards as well as essential questions and understandings. Unlike the teachers who just pick up a text book and teach from cover to cover, Understanding by Design requires that teachers determine the goals and then plan the lessons and choose the textbook sections they need to cover (Wiggins, 1998). The “stages in the backward design process are: identify desired results, determine acceptable evidence and plan learning experiences and instruction” (Wiggins, 1998, 9). Educators must first look at the state and local standards to determine what their desired results for a course are. If a district has a well
written curriculum document already created this process is very easy. However, if the curriculum document is not available, writing the curriculum for a course should be the first objective. It is important that the goals of a course are clear to the teacher and the students, if they are not clear then neither the teacher or the students know where they are headed.

Once the teacher has identified the desired results they can then determine what they would consider acceptable evidence of learning. Evidence does not only need to be in the form of test, quizzes and projects but can also be collected through formative assessments. Since the desired results of the unit are clear to the teacher using formative assessments allows students to demonstrate to the teacher on more than one occasion that they have achieved the desired results. Allowing students multiple chances to demonstrate their knowledge is important in indicating understanding of the content. Students may not be able to indicate on one type of assessment that they have learned the material but on another assessment may be successful in demonstrating their new knowledge.

After acceptable evidence is established the teacher must plan the learning experiences; the activities, notes, instruction, practice, etc. that they will include in the unit. They decide the most effective ways to help students achieve the goals of the unit, and use formative assessments throughout to plan other learning experiences as needed. It is not always possible for a teacher to account for all activities that they will use throughout a unit because the needs of the learners are not the same every year or in every class period. The Understanding by Design model allows for the change very easily because the goals will remain the same no matter how the learning experiences are
designed. It is during this stage of the planning process that teachers should use differentiated instruction techniques. They should plan for the variety of needs of the learners in their classroom, as much as they can anticipate.

The fusion of differentiated instruction and Understanding by Design is essential for effective classrooms. In order to have an effective classroom a teacher must have a well written curriculum, engaging learning activities that are catered to the needs of learners, and a safe learning environment. “In tandem, Understanding by Design and differentiated instruction provide structures, tools, and guidance for developing curriculum and instruction based on our current best understandings of teaching and learning” (Tomlinson & McTighe, 2006, 3). Using a combination of these tools in a classroom can only cause more success for the teacher and students in achieving their teaching and learning goals.

Research on Differentiated Instruction

The basis of differentiated instruction, including Vygotsky’s zone of proximal development, Gardner and Sternberg’s multiple intelligence theories, and Csikszentmihalyi and Csikszentmihalyi’s theory of flow have all been studied for years, however, there has not been a substantial amount of research done on the effectiveness of differentiated instruction itself. There are many case studies of particular classrooms in schools around the country, but nothing comprehensive. Carol Ann Tomlinson has published books and articles about her experiences using differentiated instruction and observed teachers who use differentiated instruction, but her accounts are not based on a research study. If teachers, schools and districts are to support differentiated instruction, they first want to know that it works. They want to know that they can use
it effectively and see improvements in student learning. Without research to support the theories and strategies of Carol Ann Tomlinson and other teachers across the country, no general conclusions can be made about the efficacy of differentiated instruction on student learning. There is a definite gap in the literature, and a need for further research in this area (Tomlinson & Allan, 2000).

APPLICATION

In order to apply differentiated instruction in the mathematics classroom the teacher must make sure that the goals are clear, determine acceptable evidence for the content standards and then plan engaging and valuable learning experiences. Mathematics classes are often the most traditional of classrooms, following the lecture, notes and homework format that occurred in the 1950s. With the help of Understanding by Design and differentiated instruction techniques, the following unit plan has been created.

The course that this unit has been designed for is a local Geometry course. The students in this course do not take the state exam at the end of the year, they take a teacher made final exam. The students in this course are generally students that were not successful in their Algebra course and need to move at a slower pace in order to be successful in mathematics. There are also students who were not successful in Algebra strictly because they did not do their work; they lack motivation are very good at avoiding completing assigned work. The unit is designed with the varying levels of ability and motivation in mind, it attempts to engage students in work that is meaningful and at a level that they can understand. The unit chosen for this project is Parallel and Perpendicular Lines. This unit was selected because it is a major component of any
Geometry course around the world, it introduces theorems and postulates as well as important vocabulary. The concepts of parallel and perpendicular lines and planes are threaded throughout any Geometry curriculum and are the basis for many proofs. Although this group of students does not complete formal proofs as part of the course, students who show ability and understanding working with the concepts associated with parallel and perpendicular lines are given the opportunity to write some simple proofs. Students are also given the chance to be experts and work with other students who need assistance. This type of cooperative learning gives students a good sense of self and motivates some students to achieve at a level they never thought possible.

The unit design begins with the concepts, then indicates the desired results, acceptable evidence and ends with the learning plan. Many of the activities are included in the appendix and are listed in the table of contents.

**Unit 3: Parallel & Perpendicular Lines**

**Concepts:**
Properties, relationships, parallel lines, perpendicular lines, ratio, slope, and linear relationships

**Desired Results**

**Essential Questions:**

1. How can two lines be proven parallel, not parallel, perpendicular or not perpendicular?
2. In what ways can a linear relationship be shown?
Enduring Understandings:

1. The relative measure of an angle pair involving parallel lines is determined by their relationship (some pairs are equal measure, the others are supplementary).

2. Lines can be prove parallel by comparing measures of angle pairs when the lines are cut by a transversal or comparing measure of the slopes of the lines.

3. Linear relationships can be represented graphically or algebraically.

4. The relationship between two lines is determined by their slopes.

Content Knowledge:

*Student will know…*

1. Alternate Interior Angles Theorem (and converse)

2. Alternate Exterior Angles Theorem (and converse)

3. Corresponding Angles Postulate

4. Consecutive Interior Angles Theorem (and converse)

5. Perpendicular lines have negative reciprocal slopes

6. Parallel lines have equal slopes

Skills:

*Students will be able to…*

1. Identify angle pairs formed by two lines cut by a transversal
   
   a. Alternate interior angles

   b. Alternate exterior angles

   c. Corresponding angles
2. Use the following theorems/postulates and their converses in algebraic situations
   a. Alternate Interior Angles Theorem
   b. Alternate Exterior Angles Theorem
   c. Corresponding Angles Postulate
   d. Consecutive Interior Angles Theorem

3. Find the slope of a perpendicular line given the equation, slope of graph of a line.

4. Determine whether two lines are parallel, perpendicular, or neither given their equations, slopes or graphs.

5. Write an equation of a line given a set of conditions, including:
   a. A point and equation of perpendicular or parallel line.
   b. A point and a slope.

6. Use perpendicular line theorems in proof outlines.

Assessment Evidence

Performance Tasks:

1. Angle Pairs Exit Card

   Topics: angle pairs, non-parallel lines

   Summary: After students have learned about and practiced with special angle pairs that exist within non-parallel lines they determine from a diagram each special pair of angles.

   Context of Use: This formative assessment is completed in class and is not graded. The student identification of angle pairs will inform the teacher of potential misunderstanding that need to be addressed through instruction/practice.
2. Proving Parallel Lines Exit Card

**Topics:** angle pairs, parallel lines

**Summary:** After students have learned about and practiced with parallel line theorems they use parallel line theorems to answer questions about the angle pair relationships that exist.

**Context of Use:** This formative assessment is completed in class and is not graded. The student identification of angle pairs will inform the teacher of potential misunderstanding that need to be addressed through instruction/practice.

3. Angle Pairs & Proving Parallel Lines Stations

**Topics:** angle pairs, parallel lines, non-parallel lines

**Summary:** Based on student performance on the two previous exit cards students are assigned vocabulary using the frayer model, and two practice worksheets at different levels. Students use a task card to keep track of their progress and participation. The task card must be initialed by a teacher in order for the student to move onto the next task.

**Student Directions:** Your task is to complete vocabulary and two levels of practice assignments about angle pairs and parallel lines. Using a task card you will check off assignments completed, and grade your productiveness for the class period. The teacher will initial each assignment after it is completed and then give you the next task.

**Context of Use:** This is an opportunity for students to remedy any misunderstandings that they have and to deepen their level of understanding about parallel lines and angle
pairs by using theorems to answer questions about parallel lines and angle pairs.

4. Equations of Lines Pre-Assessment

**Topics:** equations of lines, slope, y-intercept, graphing

**Summary:** This formative assessment is complete in class and is not graded. The student has to recall what they learned in Integrated Algebra to answer the questions. This pre-assessment will inform the teacher of what students remember about graphing lines, and therefore what they must focus on in instruction.

**Context of Use:** The results of this assessment will determine the instruction the following day in class. If students perform well, then the teacher just has to give students an overview of graphing equations of lines and then can move into parallel and perpendicular lines. However, if results are considerably varied or very poor then the teacher must review how to graph equations of lines and give students more practice.

5. Graphing Equations of Lines Exit Card

**Topics:** equations of lines, slope, y-intercept, graphing

**Summary:** After students have reviewed how to graph lines they graph three equations of lines (one vertical, one horizontal, and one in the form $y = mx + b$).

**Context of Use:** The results of this assessment will determine the amount of practice/instruction that students need on graphing equations of lines.

6. Writing Equations of Lines Exit Card

**Topics:** equations of lines, slope, y-intercept

**Summary:** Students answer questions about equations of lines, one with slope and y-intercept given, and the other a point and a slope.
7. Stations Task Card

**Topics:** Graphing, equations of lines, slope, y-intercept, parallel, perpendicular

**Summary:** This task card allows the student and teacher to keep track of student progress on different tasks involving graphing, and writing equations of lines. It also allows students to self-assess on their participation daily, as well as reflect on the effectiveness of the stations activity.

**Context of Use:** The teacher will be able to keep track of students progress, and then pinpoint what each student needs extra practice with. Also, the reflection piece is useful in designing future activities for the class. If the reflections are positive then the teacher should use this type of activity again, if not then it should not be used in the future.

**Other Evidence:**

- **Selected-response/short-answer test/quiz:**
  - Parallel Lines & Angle Pairs Quiz
  - Parallel & Perpendicular Lines Quiz
  - Parallel & Perpendicular Lines Test

- **Observations:** Teacher observations of students during work on the performance tasks and during class instruction/practice.

- **Student Self-Assessments:**
  - Stations Task card—participation, reflection
  - Using Parallel Lines & Transversals Practice A
  - Online survey after the unit test
Learning Plan

1. Begin with asking students what they remember about parallel lines, what does it mean for lines to be parallel?

2. Introduce the essential questions and discuss the use of the survey at the end of the unit.

3. Introduce non-parallel lines and angle pairs. Key vocabulary terms are introduced through a PowerPoint presentation. Students take notes on identifying lines and pairs of angles.

4. Take students to the computer lab to complete a Geometer's Sketchpad activity, Investigating Angle Pairs and Parallel and Non-parallel Lines. In this activity students start with non-parallel lines and record the angles measures in the diagram. Then using the construct tool they construct a parallel line, and measure all eight angles. Students then make observations about the angle pair relationships and the measures of the angles when the lines are parallel.

5. Students complete Angle Pairs Exit Card.

6. As a class discuss the observations that students made about parallel lines and angle pair relationships. Then give notes on the parallel line postulates and theorems.

7. Students write the converses of the parallel line postulates/theorems, and then write as biconditional statements since both the original and converse are true.

8. Students practice using parallel line theorems in algebraic situations.
9. Students self assess their success on the homework assignment *Using Parallel Lines & Transversals Practice A* and turn in to teacher.

10. Teacher shows students by example how to solve two of the practice questions, using out-loud thinking; showing that if they fill in all of the information that they know first, then think about the relationship between the angles they will be more successful. Students then complete *Use Parallel Lines & Angles Practice*, on their own or in pairs (student choice). The teacher is available for assistance during this time.

11. The teacher presents notes/examples on using the converses of parallel line postulates and theorems to determine that two lines are parallel.

12. Students complete *Proving Parallel Lines Exit Card*.

13. Students are assigned vocabulary and two leveled practice activities to complete over two class periods. They use a stations task card to keep track of their progress, productiveness and to reflect on the activity.

14. Students complete *Equations of Lines Pre-Assessment*.

15. Students take the *Parallel & Perpendicular Lines Quiz*.

16. Teacher reminds students how to graph equations of lines, not written in 

\[ y = mx + b \]

form and then students practice for homework. The results of the pre-assessment indicated that all students needed some instruction on graphing equations of lines.

17. Students complete *Writing & Graphing Equations of Lines Practice*. 

25
18. Teach gives notes on finding and using slopes of lines. These notes are guided
notes due to the amount of graphing involved.

19. Students complete *Graphing Parallel & Perpendicular Lines Practice*.

20. Teacher demonstrates to students how to write and graph equations of lines, and
write the equations of parallel and perpendicular lines given slope and y-
intercept.

21. Students are given a *Station Task Card* and asked to complete five different
practice activities. Since the tasks are very sequential by nature, students do not
sit in stations and rotate; instead they all start with the same practice sheet and
work at their own pace. Once students have complete one task they turn it in to
the teacher to be checked and move onto the next task. At the end of the period
students self-assess on participation. After the second day of the stations
students reflect on the activity by answering two questions.

22. Students will be given instruction and practice in small groups based on their
needs. Those students who were successful in the stations will be experts, and
will give instruction to a small group of students. The teacher and teacher’s aide
in the classroom will also give instruction in small groups.

23. Students will complete review questions for homework.

24. Students will take a summative assessment *Parallel & Perpendicular lines Test*.

25. Students will answer survey questions based on the teaching and learning in this
unit.
DATA ANALYSIS

Only twelve out of the thirty-five possible participants returned the parent consent form to participate in the research survey. Students signed their consent forms during class, and then took home the parent consent form to get signed. This low return of parental consent forms was slightly problematic because it caused the sample size to be very small. Students took the online survey before the study began and after the Parallel and Perpendicular Lines unit was completed. For the two units preceding the Parallel and Perpendicular Lines unit students were taught in a traditional fashion. I gave formal notes on the board and students copied them in their notebooks. The students then were assigned daily homework out of their textbook to be checked the next day during class. They were given one to two quizzes and a unit exam for the first two units; no other assessments were given. As shown in the unit plan students were given a variety of different learning experiences and activities during the Parallel and Perpendicular Lines unit. They were also assessed on a regular basis both formally and informally. Students did have homework assignments, but not all of their work was from the textbook and they were also given time in class to complete practice questions and activities other than notes.

Survey Data

The results of the online survey for the twelve participating students are shown in the table below. The left hand column is the question number corresponding to the survey question. Each question's options are indicated in the grey and the results are indicated in below the choices for each question asked. Students did not have the option to skip any of the questions; the online survey required that all questions be answered in
order to submit the survey. *Table 1* indicates the results of the survey before

differentiated lessons were used, and *Table 2* indicates the results of the survey after
differentiated lessons were implemented.

*Table 1: Learning Mathematics Survey Results Before Differentiated Instruction*

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### Table 2: Learning Mathematics Survey Results After Differentiation Instruction

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In order to analyze the differences between the responses to each question, each choice was given a numerical value. The mean, standard deviation and t-statistic were calculated for each individual question to determine if there were any differences in student responses. Since the surveys were anonymous the results could not be analyzed using matched pairs. Therefore, the two surveys were treated as two separate groups of students and analyzed using a t-test. The null hypothesis was that the two means were equal, showing no difference between student responses to the two different types of instruction. The alternate hypothesis was that the two means were not equal, showing that there was a significant difference in student responses to the two different types of instruction. The values for the responses were determined based on desired answers. It would be desirable for students to agree, or indicate that the pace was just right, or that
the test was fair; so those were given the highest values. If students answered too fast, too slow, too easy, too hard then those were all assigned a value of zero because they are essentially equivalent for the purpose of this study; meaning that the work or pace was not on target.

Table 3: Question Response Values

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Analysis

Once the values were assigned to the specific question responses, the mean, standard deviation and t-statistic were calculated for each individual question. The responses to each survey question are shown in Table 4 and Table 5. However, student one in the before differentiated instruction table is not matched with student one from the after differentiated instruction table. The surveys were completed anonymously online, so matching student responses before and after was not possible.
Table 4: Student Responses Before Differentiated Instruction

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Table 5: Student Responses After Differentiated Instruction

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At a glance it looks as if the students' attitudes changed for the worse after using differentiated instruction techniques. Therefore, it was important to look at each individual question to determine if students attitudes changed based on any specific aspect of the teaching. In order to determine if there was a significant difference between the responses on the surveys the t-statistic was calculated and is indicated in Table 6. The t-score was calculated using a two tail t-test with $\alpha = 0.01$, and 22 degrees of freedom; so $t = 2.819$. All of the calculated t-statistics for each question fell within the accept region. Therefore, even though at a glance it seemed that students' responses were different after differentiated instruction, there were no significant differences.

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CONCLUSIONS

The results of the survey did not indicate any significant differences between using traditional instruction and differentiated instruction in the mathematics classroom. This fact is interesting due to the major changes that were made in instruction. Looking back at the data, it looked as if the students were responding negatively to the new type of instruction. Even though it may not be statistically significant to speak of, it is worth it to discuss why students may have responded more negatively. Students in this study
have been in school at least ten years, and most of them are not high achieving students. Therefore, any type of change that is out of their comfort zone can have a negative effect on their attitude, motivation, or learning. This negative response to change is often attributed to students who have special needs or attention deficit disorder. The change for those types of students is completely overwhelming. The changes made in the classroom in order to use differentiated instruction techniques may have been overwhelming for this group of students. However, the analysis of differentiated instruction cannot be left to a single survey.

The premise of differentiated instruction is that the teacher determines and responds to the needs of the students in the classroom. In order to respond to the needs of the students the teacher must use different types of formative assessment to collect data about the students, and then make decisions about how to best help them succeed. Using a single survey is just like having a single test in a classroom; which is exactly what differentiated instruction is designed to prevent.

The formative assessments in this unit were effective in determining student ability levels and allowed the teacher to create assignments catered to the needs of those students. Students appreciated the response to their needs because they are aware that not all students learn at the same pace and that not all students will achieve at the same level. Having tiered assignments such as Proving Lines Parallel, allowed students to work at their own pace and scaffold their new knowledge. In the Proving Lines Parallel assignment students who were “clear as glass” on the content were given simple proofs and a mini lesson from the teacher, students who were “buggy” completed an assignment that was right on target for the learning goals, and students who were
“muddy” completed an assignment that progressed from below the learning goals to reaching the learning goals. This activity went very well in the classroom. All students were working hard and needed minimal assistance from the teacher. Students who were “clear as glass” felt very special that they had the opportunity to complete an assignment that was more difficult than what everyone else was working on. Students who were “muddy” were grateful that the teacher created something that was at their level and eventually led up to the more difficult questions that were in line with the learning goals.

Students also responded well to the Investigating Parallel and Non-Parallel Lines and Angle Pairs activity using Geometer’s Sketchpad. Using the technology gave students a different way to learn and allowed them to see the angle measures change. This discovery and technology based activity allowed students to easily see what was happening and be more active in their own learning. After this lesson, if a student asked about angle pair measures, I would mention the activity and ask “How many different angle measures did we see when the lines were parallel”? This question clued students in to the fact that when the lines are parallel there are only two different angle measures, so the only fact that need to determine is whether or not there are congruent or supplementary. This was a great prompt to use without giving the answer. The survey also indicated that this learning activity was engaging and effective for student learning.

Not all of the differentiated instruction techniques were implemented perfectly. The Parallel and Perpendicular Lines Stations activity did not go as smoothly and was not as effective as I had intended. In the activity there were five stations (or tasks) that students progressed through. The first station was Graphing Equations of Lines, which is the prior knowledge needed to graph parallel and perpendicular lines. The stations
progressively added new content knowledge and skills, and therefore became more difficult for students. Students completed the first two stations fairly easily, but then began to have difficulty with graphing parallel and perpendicular lines, which is the new knowledge for the unit. Students became frustrated and I had to stop the stations to give more formal instruction on how to graph parallel and perpendicular lines.

Although the stations were not effective initially, I used differentiated instruction again by responding to the frustration of the students in the class. Students who knew how to complete the parallel and perpendicular lines stations just kept working while those who needed it received a mini lesson from the teacher. Ultimately the activity was successful, but the level of frustration for the students during the activity changed their attitudes and could have been a factor in the negative responses on the end survey.

Overall, using differentiated techniques in the mathematics classroom was very effective in getting students to think and practice on their own at an appropriate level. The formative assessments were essential to knowing exactly what each student was learning and what needed to be re-taught. The pre-assessments were intended to create tiered lessons the following class, but indicated that students did not remember the information and that it needed to be re-taught. This would not necessarily be true for every group of geometry students, but because the course was written for students who had difficulty in Algebra it was not a surprise that they did not have the prior knowledge that they needed. The activities and assessments allowed me to assess students' conceptual understanding by providing written evidence and observations of student thinking.
RECOMMENDATIONS

Using differentiated instruction in the mathematics classroom proved to be effective in meeting students' needs and keeping the teacher informed for what those needs were. The use of formative assessments provided the information necessary to design instruction appropriate for the students in the classroom. Using tiered assignments gave students work that was at a level they could understand, yet brought on new learning. The task cards for the stations activities gave students an agenda, so that the goals were clear as well as providing an opportunity for self assessment. All of these differentiated instruction techniques were effective in the mathematics classroom in a variety of ways. They proved to meet the needs of the teacher and student in achieving the unit standards and overall unit goals.

Before a teacher can differentiate their instruction they must have a clearly written curriculum. In order to begin teaching they must know where they are headed, so the desired results must be clear. They can then determine acceptable evidence for reaching the desired results and finally begin to plan learning activities (Wiggins & McTighe, 1998). They must also have a healthy learning environment, where there is an equal balance between the teacher, the students, and the content (Tomlinson, 1999, 27). In other words differentiated instruction does not replace a good curriculum, planning, instruction or classroom management. It is an instructional set of tools that aid in the delivery of instruction and learning for understanding.

Implementing differentiated instruction into any classroom is not an easy task, but is something that is worthwhile for the teacher and students. Many teachers are apprehensive about change, and the impact it may have on their students. By starting
with formative assessment as a small change in the classroom, the only change is for the better. The teacher will only have more information about student learning, and will not have made any major changes in their instruction. Differentiation will come naturally after formative assessments have been used because the teacher will easily see the needs of their students and will want to change instruction based on those needs.

Changing instruction based on student needs is important in helping them reach their learning goals. However, changing too much in the classroom at once can cause students to become overwhelmed, especially those who have special needs or are not high achievers. Students like to know what to expect in a classroom, and feel in control of their own learning. Using differentiated instruction should be a gradual process so that students do not shutdown. Too many big changes could be detrimental to student learning.

There is a lot of research on student learning in a multitude of different classrooms and schools throughout the world. However, there is not a lot of research on the effectiveness of differentiated instruction in the classroom. Differentiated instruction techniques are based on brain research, multiple intelligences, scaffolding and common sense. There is plethora of literature and studies on the brain, multiple intelligences and scaffolding which is why experts can say that differentiated instruction is effective in the classroom. There needs to be more research done on the implementation of differentiated instruction in different content areas, especially mathematics. Mathematics teachers seem to be the most apprehensive about using differentiated instruction techniques in their classroom because they feel that it will take away the amount of material that they can cover. If these teachers had statistical
evidence that showed that differentiated instruction was effective in teaching mathematics courses that resulted in a high-stakes test they would be more open to the idea of using differentiated instruction in their own classrooms.

Teaching and learning are constantly changing. Research is being done daily on what is most effective for students in the classroom. It is an educator's responsibility to be up to date on the research and teach in the most modern fashion. Teacher's who refuse to change their ways because they are comfortable are doing their students in injustice. If Harper Lee knew about differentiated instruction in 1960 he may have written the interaction between Scout and Miss Caroline differently. He could have had Miss Caroline ask Scout to teach some of the younger children how to read while she worked with the older children. She also could have given Scout higher level reading in the classroom. Scout needed to be challenged beyond what was being presented in the classroom and Miss Caroline did not respond to those needs.

Although Miss Caroline did not know how to teach in any other way, research and literature has shown present day educators that they can teach to meet the needs of their students. Using differentiated instruction in the classroom provides teachers with a variety of tools to help meet students' needs to reach their learning goals. Meeting students needs is the goal of any teacher, and they should use any method possible to help students reach their goals and be successful in the classroom.
REFERENCES


Survey Questions

1. Are you male or female?

2. Do you feel that class instruction and work time was well spent?
   Agree       Somewhat       Disagree

3. Did you feel that the work you were given was at a level you could understand?
   Too Easy    Just Right     Too Hard

4. Were you successful throughout this unit (think about homework, participation, and classwork)?
   Agree       Somewhat       Disagree

5. Were the goals of the unit clear to you from the beginning?
   Agree       Somewhat       Disagree

6. Were you given multiple chances (more than 2) to show your teacher what you learned?
   Agree       Somewhat       Disagree

7. Did you feel that the unit test was a fair assessment of what you learned?
   Too Easy    Fair           Too Hard

8. The pace of the unit was....?
   Too Slow    Just Right     Too Fast

9. Describe one thing (lesson/activity/assignment) that you really LIKED during this unit.

10. Describe one thing (lesson/activity/assignment) that you really DISLIKED during this unit.
Student Responses to Survey Questions 9 and 10 Before Differentiation

Question #9: Describe one thing (lesson/activity/assignment) that you really LIKED during this unit?

1. One thing that I liked about this unit was that the lessons were too easy, I understood everything. The converse, inverse and contrapositive stuff were very easy things that I learned a long time ago. The homework wasn’t bad either.

2. I liked learning how to write different sentences with the contrapositive, converse, and inverse.

3. I liked the lesson when we did the steps for finding x.

4. I liked the word problems.

5. Figuring out the next picture to draw.

6. Pretty much I enjoyed just learning the stuff, it sounds sad but true.

7. The shape pattern thing.

8. One thing that I liked about this unit was writing conditional statements.

9. I like how we take somewhat a lot of notes and talk about the problems more because I understand more and get more right.

10. That I was able to understand most of it.

11. I really liked the patterns we did. Figuring out what number was coming up next because that was easy.

12. The lesson was easy to understand.
Question #10: Describe one thing (lesson/activity/assignment) in this unit that you disliked.

1. One thing I dislike about this unit was the way the teacher taught the unit.
2. The patterns with pictures.
3. I didn’t like writing the sentences with the strips of paper.
4. I didn’t like taking notes.
5. I don’t like making conjectures.
6. I disliked the fact that sometimes learning it slow made me feel stupid.
7. All the writing.
8. One thing I disliked about this unit was the law of detachment and law of syllogism.
9. I did not like the counterexamples because they were confusing and I didn’t quite understand them.
10. There were a few things in that unit that I couldn’t understand but after a little time I was able to understand it.
11. I don’t like trying to remember what one is inverse, contrapositive, or conjecture. I can’t remember them. So that is hard and I don’t like it.
12. Taking notes.
Student Responses to Survey Questions 9 and 10 After Differentiation

**Question #9:** Describe one thing (lesson/activity/assignment) that you really LIKED during this unit?

1. Parallel lines.
2. Graphing.
4. I liked graphing all the line on the graph.
5. I liked the part with finding the equation of the line.
6. The lines.
7. Nothing.
8. I liked doing the colored sheets (stations).
9. Going slow and taking somewhat of time to get through it.
10. Activity on the laptops (*Geometer's Sketchpad*).
11. Graphing easy lines.
12. I liked working with someone because we could get double the help (stations/agendas).

**Question #10:** Describe one thing (lesson/activity/assignment) in this unit that you DISLIKED.

1. Negative slopes.
2. Most of it.
4. I disliked the algebra in the unit.
5. I didn't like the part where we had to figure out if the lines were perpendicular.

6. The $y =$ stuff.

7. Everything.


9. Graphing I think that it is too hard.


11. What we just did (stations).

12. The colored sheets were a little too hard (stations).
Figure 1: Identify Angle Pairs Practice (Front)

Identify Angle Pairs Practice

Classify the angle pair as corresponding, alternate interior, alternate exterior, or consecutive interior angles.

1. \(41\) and \(49\)

2. \(48\) and \(413\)

3. \(46\) and \(416\)

4. \(44\) and \(410\)

5. \(410\) and \(416\)

6. \(410\) and \(413\)

7. \(43\) and \(49\)

8. \(45\) and \(413\)

9. \(44\) and \(410\)

10. \(45\) and \(415\)

11. \(47\) and \(414\)

12. \(41\) and \(411\)

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In questions #13-16, use the markings in the diagram.

13. Name a pair of parallel lines.

14. Name a pair of perpendicular lines.

15. Is $\overline{DE} \parallel \overline{EF}$? Explain.

16. Is $\overline{DE} \perp \overline{EF}$? Explain.
Figure 3: Investigating Angles and Parallel & Non-Parallel Lines

Geography: Geometry A
Miss Newman: Name: ____________________________
Date: ____________________________

Investigating Angles and Parallel & Non-Parallel Lines

Non-Parallel Lines
Record the angle measures for step #2.

| Angle  | \( \angle \text{AGH} \) | \( \angle \text{HGB} \) | \( \angle \text{AGF} \) | \( \angle \text{BGF} \) | \( \angle \text{CHG} \) | \( \angle \text{GHD} \) | \( \angle \text{CHE} \) | \( \angle \text{DHE} \) |
|--------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Measure|                  |                  |                  |                  |                  |                  |                  |                  |

Parallel Lines
Record the angle measures for step #12-13.

<table>
<thead>
<tr>
<th>Angle</th>
<th>( \angle \text{AGH} )</th>
<th>( \angle \text{HGB} )</th>
<th>( \angle \text{AGF} )</th>
<th>( \angle \text{BGF} )</th>
<th>( \angle \text{CHG} )</th>
<th>( \angle \text{GHD} )</th>
<th>( \angle \text{CHE} )</th>
<th>( \angle \text{DHE} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stop and Observe: What observations can you make about the alternate interior angles, corresponding angles, alternate exterior angles, vertical angles, and the consecutive interior angles for the PARALLEL lines?

How many different angle measures do you see? ________

<table>
<thead>
<tr>
<th>Angle Pairs</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate interior angles</td>
<td></td>
</tr>
<tr>
<td>Corresponding angles</td>
<td></td>
</tr>
<tr>
<td>Alternate exterior angles</td>
<td></td>
</tr>
<tr>
<td>Vertical angles</td>
<td></td>
</tr>
<tr>
<td>Interior angles on the same side of the transversal</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4: Investigating Angle Pairs and Parallel & Non-Parallel Lines (Front)

Investigating Angle Pairs and Parallel & Non-Parallel Lines

1. To open the Geometer's Sketchpad document:
   - My Computer
   - Student work drive (X:)
   - NEWMAN folder
   - Investigating Angle Pairs and Parallel & Non-Parallel lines

2. In the top left hand corner are the angle measures, record these in your table for the Non-Parallel Lines.

3. Highlight $CE$ and point $D$ by clicking on both. Press DELETE.

4. Highlight $AB$ and point $E$ by clicking on both.

5. Select the CONSTRUCT menu at the top of the page, then select PARALLEL LINE.

6. Select the point tool (the dot), and place it on the new line where $D$ was before.

7. Using the point tool, place a point where $B$ used to be. Make sure that both lines highlight blue when you place the intersection point $E$. 
8. Select the ARROW tool. Highlight only point D, then go to the DISPLAY menu and select LABEL POINT, type in D.

9. Repeat for intersection H.

Now we need to measure the new angles.

10. The measures of ∠AGF and ∠BGF should still be in the top left corner.

11. To measure the other angles, select the points in the same order as they appear in your table. MAKE SURE NOTHING ELSE IS HIGHLIGHTED except those points.

12. Select the MEASURE menu, and choose ANGLE.

13. Repeat for all angles, and record in your table.
Figure 6: Angle Pairs Exit Card

Geometry A
Miss Newman

Name: ___________________________
Date: ___________________________

Angle Pairs Exit Card

Directions: Based on the picture below, name a pair of angles that fit the classification.

1. Alternate Exterior Angles
2. Alternate Interior Angles
3. Consecutive Interior Angles
4. Corresponding Angles
5. Vertical Angles
Using Parallel Lines & Transversals Practice A

What postulate or theorem justifies the statement about the diagram?

1. \( \angle 1 = \angle 5 \)

2. \( \angle 4 \) and \( \angle 6 \) are supplementary.

3. \( \angle 4 \) and \( \angle 5 \)

4. \( \angle 2 = \angle 7 \)

Find \( m\angle 2 \) and \( m\angle 7 \).

5. \( \angle 120^\circ \)

6. \( \angle 60^\circ \)

7. \( \angle 45^\circ \)

8. \( \angle 30^\circ \)

9. \( \angle 110^\circ \)

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Figure 8: Using Parallel Lines & Transversals Practice A (Back)

Find the values of $x$ and $y$.

10. \[ x = 90° \]

11. \[ 120° \]

12. \[ 130° \]

Find the value of $x$.

16. \[ 80° \]

17. \[ 120° \]

18. \[ 110° \]

19. \[ (x - 10)^° \]

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use Parallel Lines & Angle Pairs Practice

Find the angle measure, AND tell which postulate/theorem you use.

1. If \( m\angle 1 = 50\), then \( m\angle 5 = \) ______ by the ______

2. If \( m\angle 4 = 45\), then \( m\angle 6 = \) ______ by the ______

3. If \( m\angle 3 = 130\), then \( m\angle 7 = \) ______ by the ______

4. If \( m\angle 6 = 123\), then \( m\angle 3 = \) ______ by the ______

Find \( m\angle 1 \) and \( m\angle 2 \\
5. \\
6. \\
7. \\
8.

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Figure 10: Use Parallel Lines & Angle Pairs Practice (page 2)

Find the values of $x$ and $y$.

11.

12.

13.

14.

15.

16.

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Figure 11: Use Parallel Lines & Angle Pairs Practice (page 3)

17. Find the value of x.

18.

19.

20.

21.

22.

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1. Is there enough information to prove that the two lines are parallel? If so, state the postulate or theorem you would use.

2. Find the value of $x$ that makes $m \parallel n$. 

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Figure 13: Proving Lines Parallel- "Muddy" (page 1)

Geometry A
Miss Newman

Proving Lines Parallel

Is there enough information to prove that lines p and q are parallel? If so, state the postulate or theorem you would use.

1. 

2. 

3. 

4. 

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Figure 14: Proving Lines Parallel- "Muddy" (page 2)

5. 
\[ \text{Proving Lines Parallel} \]

6. 
\[ \text{Proving Lines Parallel} \]

Find the value of \( x \) that makes \( m \parallel n \).

7. 
\[ \text{Proving Lines Parallel} \]

8. 
\[ \text{Proving Lines Parallel} \]

9. 
\[ \text{Proving Lines Parallel} \]

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10. \(90^\circ\)
   \(m\)
   \((5x + 20)^\circ\)
   \(n\)

11. \((4x - 28)^\circ\)
    \(m\)
    \(100^\circ\)
    \(n\)

12. \((2x - 96)^\circ\)
    \(m\)
    \(n\)

13. Multiple Choice Two lines \(m\) and \(n\) are parallel. They are cut by a transversal so that \(\angle A\) and \(\angle B\) are consecutive interior angles. If \(m\angle A = 84^\circ\), what is \(m\angle B\)?
   
   A. 6°
   B. 84°
   C. 96°
   D. 276°
Exercises 14–17, use the diagram and the given information to determine if $m \parallel n, n \parallel p$, or neither.

14. $\angle 2 \equiv \angle 11$
15. $\angle 1 \equiv \angle 3$
16. $\angle 10 \equiv \angle 14$
17. $\angle 4 \equiv \angle 16$

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Proving Lines Parallel

Is it possible to prove that lines \( p \) and \( q \) are parallel? If so, state the postulate or theorem you would use.

1. \( \angle p = 58^\circ \)
   \( \angle q = 122^\circ \)

2. \( \angle p = 60^\circ \)
   \( \angle q = 26^\circ \)
   \( \angle q = 85^\circ \)

3. \( \angle p = 82^\circ \)
   \( \angle q = 40^\circ \)
   \( \angle q = 120^\circ \)

Find the value of \( x \) that makes \( m \parallel n \).

4. \( \angle m = 100^\circ \)
   \( 2x^\circ \)

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63
Figure 18: Proving Lines Parallel—“Buggy” (page 2)

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In Exercises 10-12, choose the word that best completes the statement.

10. If two lines are cut by a transversal so the alternate interior angles are (congruent, supplementary, complementary), then the lines are parallel.

11. If two lines are cut by a transversal so the consecutive interior angles are (congruent, supplementary, complementary), then the lines are parallel.

12. If two lines are cut by a transversal so the corresponding angles are (congruent, supplementary, complementary), then the lines are parallel.

13. Gardens: A garden has five rows of vegetables. Each row is parallel to the row immediately next to it. Explain why the first row is parallel to the last row.

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**Proving Lines Parallel**

Complete the two-column proof.

1. **GIVEN:** \( g \parallel h \) \( \equiv 1 \equiv 2 \)
   **PROVE:** \( p \parallel r \)

<table>
<thead>
<tr>
<th>Statements</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( g \parallel h )</td>
<td>1.</td>
</tr>
<tr>
<td>2. ( \angle 1 \equiv \angle 2 )</td>
<td>2.</td>
</tr>
<tr>
<td>3. ( \angle 3 \equiv \angle 2 )</td>
<td>3.</td>
</tr>
<tr>
<td>4. ( \angle 3 \equiv \angle 3 )</td>
<td>4.</td>
</tr>
<tr>
<td>5. ( p \parallel r )</td>
<td>5.</td>
</tr>
</tbody>
</table>

2. **GIVEN:** \( g \parallel h \) \( \angle 1 \equiv \angle 2 \)
   **PROVE:** \( p \parallel r \)

<table>
<thead>
<tr>
<th>Statements</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>( g \parallel h )</td>
<td>1.</td>
</tr>
<tr>
<td>( \angle 1 \equiv \angle 3 )</td>
<td>2.</td>
</tr>
<tr>
<td>( \angle 1 \equiv \angle 2 )</td>
<td>3.</td>
</tr>
<tr>
<td>( \angle 2 \equiv \angle 3 )</td>
<td>4.</td>
</tr>
<tr>
<td>( p \parallel r )</td>
<td>5.</td>
</tr>
</tbody>
</table>

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3. GIVEN: \( n \parallel m, \angle 1 = \angle 2 \)
PROVE: \( p \parallel r \)

<table>
<thead>
<tr>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n \parallel m )</td>
</tr>
<tr>
<td>( \angle 1 = \angle 3 )</td>
</tr>
<tr>
<td>( \angle 1 = \angle 2 )</td>
</tr>
<tr>
<td>( \angle 2 = \angle 3 )</td>
</tr>
<tr>
<td>( p \parallel r )</td>
</tr>
</tbody>
</table>

4. GIVEN: \( p \perp q, q \parallel r \)
PROVE: \( p \perp r \)

<table>
<thead>
<tr>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p \perp q )</td>
</tr>
<tr>
<td>( \angle 1 ) is a right angle</td>
</tr>
<tr>
<td>( q \parallel r )</td>
</tr>
<tr>
<td>( \angle 1 = \angle 2 )</td>
</tr>
<tr>
<td>( \angle 2 ) is a right angle</td>
</tr>
<tr>
<td>( p \perp r )</td>
</tr>
</tbody>
</table>

4. Bowling Lanes A recreation center has four bowling lanes (1, 2, 3, 4). Each lane is parallel to the lane immediately next to it. Explain why the first lane is parallel to the last lane.

5. Railroad Tracks Two sets of railroad tracks intersect as shown. How do you know that line \( n \) is parallel to line \( m \)?

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Equations of Lines Pre-Assessment

1. Find the slope of the line that passes through the points on the graph below.

2. Tell which line has a steeper slope.
3. Write the equation of the line with a slope of 2 and a y-intercept of 3.

4. Graph the line $y = \frac{1}{2}x + 1$ on the grid below.
Figure 24: Writing & Graphing Equations of Lines (page 1)

Writing & Graphing Equations of Lines

From a graph:
1. 
   ![Graph 1](image1)

2. 
   ![Graph 2](image2)

3. 
   ![Graph 3](image3)

4. 
   ![Graph 4](image4)

5. 
   ![Graph 5](image5)

6. 
   ![Graph 6](image6)

Given the slope and y-intercept, write the equation and the equation of lines parallel & perpendicular.

<table>
<thead>
<tr>
<th></th>
<th>Equation</th>
<th>Parallel Line</th>
<th>Perpendicular Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>m = 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b = -1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>m = -\frac{1}{2}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b = 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>m = 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b = \frac{1}{2}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>m = 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b = 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Write an equation of the line that satisfies the given conditions.

11. parallel to \( x + 2y = 6 \); passes through (1,1)

12. parallel to \( 2x - 4y + 4 = 0 \); passes through (-2,3)

13. perpendicular to \( x + y = 0 \); passes through (0,5)

14. perpendicular to \( 3x + y - 1 = 0 \); passes through (3, -1)

Write an equation of the line that is:

15. parallel to the line \( y = 2x - 4 \); and has a \( y \)-intercept of 7

16. parallel to the line \( y - 3x = 6 \); and has a \( y \)-intercept of -2

17. parallel to the line \( 2x + 3y = 12 \); and that passes through the origin

18. perpendicular to the line \( y = 3x + 2 \); and has a \( y \)-intercept of 2

19. perpendicular to the line \( 3y + 4x = 18 \); and that passes through the origin

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Writing & Graphing Equations of Lines Practice

Write an equation of the line with the given slope m and y-intercept b.

1. \( m = 2; \ b = 3 \)

2. \( m = 1; \ b = 1 \)

3. \( m = 4; \ b = 2 \)

4. \( m = 3; \ b = -2 \)

5. \( m = -6; \ b = 4 \)

6. \( m = -\frac{1}{2}; \ b = -5 \)

Write an equation of the line that passes through the given point \( P \) and has the given slope \( m \).

14. \( P(0, 2); \ m = 3 \)

15. \( P(3, 0); \ m = 2 \)

16. \( P(2, 4); \ m = -\frac{1}{2} \)

Write an equation of the line that passes through point \( P \) and is parallel to the line with the given equation.

17. \( P(1, 3); \ y = 2x - 2 \)

18. \( P(2, 5); \ y = 4x + 1 \)

19. \( P(0, 1); \ y = -x + 3 \)

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Write an equation of the line that passes through point $P$ and is perpendicular to the line with the given equation.

20. $P(4,2); \ y = \frac{1}{2} x + 4$

21. $P(3,-2); \ y = -\frac{1}{3} x - 3$

22. $P(-2,6); \ y = 2$

Identify the $x$- and $y$-intercepts of the line. Use the intercepts to write an equation of the line.

23. [Graph of a line]

24. [Graph of a line]

25. [Graph of a line]

Graph the equation.

26. $x + y = 1$

27. $3x + y = 2$

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Figure 28: Writing & Graphing Equations of Lines Practice (page 3)

28. \( x - 2y - 6 \)

29. \( 4x + 2y = 8 \)

30. \( y - 4 = x - 1 \)

31. \( 2y + 1 - 3x + 5 \)

32. Bowling League: The graph models the total cost of participating in a bowling league. Write an equation of the line. Explain the meaning of the slope and the \( y \)-intercept of the line.

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Figure 29: Parallel & Perpendicular Lines Task Card (Agenda)

<table>
<thead>
<tr>
<th>Stations Task Card</th>
<th>Score</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphing Equations of Lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing Equations of Lines</td>
<td></td>
<td></td>
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<tr>
<td>Writing Equations of Parallel Lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing Equations of Perpendicular Lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel or Perpendicular?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Participation Grades | | | |
|----------------------|--|--|
| Date | What I think I learned | What Miss Newman thinks I learned |
|       |                           |                                  |
|       |                           |                                  |
|       |                           |                                  |
|       |                           |                                  |

Geometry
Miss Newman
Figure 30: Graphing Equations of Lines, Station 1

Geometry
Miss Newman
Name:_________________
Date:_________________

Graphing Equations of Lines

1. A line goes through the point (1,3) and has a slope of \( \frac{3}{4} \).
   Graph this line.

2. Draw the graph of a line with y-intercept 5 and slope \( \frac{3}{4} \).

3. Graph: \( y = -5x + 3 \)

4. Graph: \( y = -2x - 4 \)

5. Graph: \( 4x - 5y = -20 \)

6. Graph: \( 4x - 3y = -12 \)

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Figure 31: Writing Equations of Lines, Station 2

Geometry: Name:
Miss Newman Date:

**Writing Equations of Lines**

1. Write the equation of the line that passes through the point (4, -6) and has a slope of -3.

2. Write the equation of the line that passes through the point (3, -1) and has a slope of 2.

3. What is the equation of the line that has a slope of 3 and a y-intercept of -2?

4. What is the equation of the line whose slope is 2 and whose y-intercepts is 6?

5. If (-1, 0) is on the line whose equation is y = 2x + b what is the value of b?

6. What is an equation of the line that passes through the points (3, -3) and (-3, -9)?

7. What is an equation for the line that passes through (2, 0) and (0, 3)?

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Figure 32: Writing Equations of Parallel Lines, Station 3

Writing Equations of Parallel Lines

1. Write an equation of a line that is parallel to the line whose equation $3y = x + 2$.

2. What is the equation of a line that passes through the point $(-3, 9)$ and is parallel to the line whose equation $2x - y = 4$?

3. Write an equation of the line that passes through the point $(6, -5)$ and is parallel to the line whose equation $2x - 3y = 11$.

4. Find an equation of the line passing through the point $(5, 4)$ and parallel to the line whose equation $2x - y = 3$.

5. Write an equation of the line that passes through $(3, -1)$ and is parallel to $y = 6x - 4$.

6. What is the equation of the line that passes through $(6, 5)$ and is parallel to $7y + 4x = 2$.

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Figure 33: Writing Equations of Perpendicular Lines, Station 4

<table>
<thead>
<tr>
<th>Writing Equations of Perpendicular Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the slope of a line perpendicular to the line whose equation (5x + 3y = 8)?</td>
</tr>
<tr>
<td>2. What is the slope of a line perpendicular to the line whose equation (y = -\frac{3}{2}x - 5)?</td>
</tr>
<tr>
<td>3. Write an equation of a line perpendicular to the line whose equation (2x + 3y = 12).</td>
</tr>
<tr>
<td>4. What is an equation of the line that passes through the point ((-2,5)) and is perpendicular to the line whose equation (y = \frac{2}{3}x + 5)?</td>
</tr>
<tr>
<td>5. Write an equation of the line that passes through ((3,-1)) and is perpendicular (y = 6x - 4).</td>
</tr>
<tr>
<td>6. Write an equation of the line that passes through ((-6,5)) and is perpendicular (7y + 4x = 2).</td>
</tr>
</tbody>
</table>

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Figure 34: Parallel or Perpendicular, Station 5

Parallel or Perpendicular???

Determine whether the lines through the given points are parallel, perpendicular, or neither.

1. Line 1: (8,12) and (7,-5)
   Line 2: (-9,3) and (8,2)

2. Line 1: (3, -4) and (-1,4)
   Line 2: (2,7) and (5,1)

3. AB: A(1,2) and B(2,0)
   CD: C(0,-1) and D(-2,-2)

4. EF: E(-2,1) and (1,-1)
   GH: G(1,3) and H(4,1)

5. Are the lines $3y + 1 = 6x + 4$ and $2y + 1 = x - 9$ parallel, perpendicular, or neither?

6. Determine if the two lines $5x - 7y = -35$ and $y = \frac{2}{3}x + 3$ are parallel, perpendicular, or neither.

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