A Dissertation

entitled

Differentiated Instruction: An Exploratory Study in a Secondary Mathematics Classroom

By

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Submitted to the Graduate Faculty as partial fulfillment of the requirement for the Doctor

in Philosophy Degree in Curriculum and Instruction

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This case study explores the different approaches to teaching inside a differentiated instruction classroom. The research will be conducted at a college preparatory high school with an emphasis on using various approaches to differentiated instruction to enhance students’ comprehension of Advanced Algebra II. Data collection will include students’ journal reflections, direct-observations, participant-observations, lesson plans, physical artifacts, various students’ assessments, and survey-interviews.

The study followed a mixed method design and consisted of two parts qualitative and quantitative data collection and analyses. Both data will be analyzed using excel sheets and ATLAS.ti software. In addition to studying the effects of differentiated instruction on the teacher, the focus of this study will be on mathematics differentiated instruction classroom and how the researcher will relate students’ experience in class to the quantitative outcome of the data.
This dissertation is dedicated to my wonderful husband Sonny, to my amazing two sons: Ryan and Robert, and to my proud parents across the oceans.

Sonny, your unwavering support and encouragement have carried me through to the end. I cannot thank you enough for being my wonderful mentor, coach, role model, and best friend. I love you!

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Chapter 1

Introduction

Overview

Classrooms are filled with diverse learners who differ not only culturally and linguistically, but also in their cognitive aptitudes, background knowledge, and learning inclinations. Schools across the nation are challenged with such diversity. In an attempt to enhance students’ learning, and maximize their achievement, numerous schools are implementing differentiated instruction. Hall (2002) defines differentiated instruction as:

A process to approach teaching and learning for students of differing abilities in the same class. The intent is to maximize each student’s growth and individual success by meeting each student where he or she is . . . rather than expecting students to modify themselves for the curriculum. (p. 79)

Maximizing the conceptual understanding of the material taught is the goal of any educator. With the current diversity inside classrooms, it is almost impossible for teachers to challenge all their students in the same class unless they reform the curriculum in a way to reach all students.

The National Council of Teachers of Mathematics (NCTM, 2000) recognized the necessity of differentiation in the mathematics classroom. It emphasized the need to accommodate differences among students to ensure a sound comprehension of mathematical knowledge:

Excellence in mathematics education requires equity- high expectations and strong support for all students. Equity does not mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate
accommodations be made as needed to promote access and attainment for all students. (p.12)

Some of the work included in mathematics teaching requires finding examples, linking mathematical ideas, evaluating students’ mathematical progression, and crafting accommodations to improve the instructional process and to maximize students’ achievements.

In this study, the researcher explored the seemingly continuous shift in the teaching paradigm; specifically how differentiated instruction unfolded in the classroom context.

Statement of the Problem

Recently, the disparity in students’ readiness level in any class, the imposed expectations on classroom teachers to personalize education according to individual needs, and holding teachers accountable for students’ success or failure are the new focus in mathematics classrooms. Small and Lin (2010) stated,

Differentiating instruction is not a new idea, but the issue has been gaining an ever-higher profile for mathematics teachers in recent years. More and more, educational systems and parents are expecting the teacher to be aware of what each individual student—whether a struggling student, an average student, or a gifted student—needs and plan instruction to take those needs into account. In the past, this was less the case in mathematics than in other subject areas, but now the expectation is common in mathematics as well. (p. 3)

For years, teachers understood differences among their students; in the same time, they felt the burden of covering the curriculum within the restriction of certain number of
weeks, therefore, teachers have been designing their lesson plans based on direct instruction, thinking that direct instruction is the most conducive tool of delivering knowledge to students. Various disciplines emphasize collaboration on projects, presentations, and research papers. However, given the nature of mathematics, collaboration, research projects, and alternative ways of assessing students are still novel ways of discovering knowledge and evaluating comprehension. Leinwand et al. (2014) stated,

An excellent mathematics program requires effective teaching that engages students in meaningful learning through individual and collaborative experience that promote their ability to make sense of mathematical ideas and reason mathematically. (p. 5)

Recently, research has stressed the importance of allowing students to discover, experiment, and sometime fail while learning. Embracing the new trend in education, differentiated instruction, and focusing on the result of such a methodology inside a mathematics classroom is quite fascinating in the field of teaching and learning.

Mathematics teachers are often limited to what the textbook is providing as extra tools to measure understanding. Small and Lin (2010) argue the need for mathematics teachers to understand differences among their students and to differentiate instruction accordingly. Small and Lin (2010) stated, “The math teacher will more frequently teach all students based on a fairly narrow curriculum goal presented in a textbook” (p. 1).

Teachers recognize that some students need extra help with mathematical concepts and others thrive with challenging problems. Most teachers desire to be successful in their fields. Therefore, understanding differences and differentiating
Instructional strategies may be the key to achieving our desire of being successful teachers.

The available research, on the effectiveness of using differentiation to enhance comprehension, is mainly geared towards middle to lower school students. There are fewer studies on the effectiveness of differentiation among high school students and, more specifically, in the field of mathematics.

Throughout my years of being an educator, I have coached students who are struggling with mathematical concepts. An aspect of my pedagogical context knowledge I am curious to explore is the notion of differentiated instruction and its effects, if any, on students’ comprehension of mathematical knowledge. I am intrigued by the phenomena of how students who are repeatedly exposed to a concept via a defined method still struggle with conceptual understanding of the material.

This case study aims to examine classroom practices that support different methods of differentiation with the goal of outlining students’ performance outcome and how it relates to their experience in a differentiated classroom.

This study will contribute to the literature by providing insight on how the methodology of discovering knowledge through different methods of differentiated instruction influence students’ achievement in the mathematics classroom. At the same time, this study will describe students’ experiences with the different methods of teaching based on students’ written journals. In addition, the study will examine the experience of the instructor and the significances of differentiation in the classroom.
Significance of the Study

The purpose of this study is to explore whether students’ performance outcome in mathematics relate to their experience in a differentiated instruction classroom. Examining the application of differentiated instructional strategy in upper mathematics classroom is new to the participants, therefore, having participants describe their experience, level of satisfaction, and confidence in a differentiated classroom and analyzing the correlation between their feedback and their actual score on assessments would be significant the field of mathematics. Similarly, studying teacher’s role and describing her experience in a differentiated classroom in terms of the workload, effort, and the requirement might provide a positive influence on the field. The specific research questions for the study are:

1. How does students’ performance outcome relate to their experience in a differentiated classroom?

2. What effects does the use of differentiated instruction have on the instructor?

The benefits of differentiated instruction need to be examined further. While some teachers feel the overbearing need to differentiate their instruction in classrooms, others believe it is just work and demands in terms of time and effort. Wormeli (2006) described teachers’ experiences inside a differentiated classroom as less burdened. He states:

Most teachers who dive into differentiation mind-set and practices feel liberated, not burdened. They breathe a little easier because they experience students’ learning as a direct result of their decisions, and those students are
learning at a level otherwise not achievable through non-differentiated practices.

(p. 8)

The instructional strategies educators have been implementing in traditional classrooms will be replaced by establishing a sense of discovery and appreciation of abstract thinking rather than concrete procedural thinking. In traditional classrooms, though learning might be happening at different levels, yet, success in developing and increasing students’ comprehension is eminent.

Differentiation is created based on best practices orchestrated by teachers inside the classroom. Hall (2002) perceived differentiation as a combination of many theories and best practices in the field of education. Based on the literature review, differentiation still lacks empirical validation: “There is an acknowledged and decided gap in the literature in this area and future research is warranted” (p. 4). With differentiation being the recent move in education, further research is necessary. The researcher is hoping this study will contribute to the field of education and supports the necessity of using differentiated instruction in classrooms.

Since more schools are pursuing differentiated instruction as a way to personalize education and reach each individual student in the classroom, teachers are finding themselves stepping out of their comfort zone. It is possible that teachers are not comfortable with differentiation because they may not have been trained. Small and Lin (2010) stated,

Perhaps this occurs because differentiating instruction in mathematics is a relatively new idea. Perhaps it is because teachers may never have been trained to
really understand how students differ mathematically. However, students in the
same classroom clearly do differ mathematically in significant ways. (p. 1)

Differences in classrooms can be cognitive that relates to calling upon previous skills and
knowledge, some differences may relate to learning styles where a student may be an
auditory learner, visual learner, or kinesthetic, and other differences may relate to
preferences where a student is persistent, inquisitive, or lacks personal interest.
Regardless of the differences inside classrooms, teachers have to be mindful of their
students and their interests.

This case study will provide a foundation for future findings about the
effectiveness of differentiation inside any mathematics classroom. It will provide an
insight into the need for change in the way teachers are: a) being trained and in b)
educating students.

Definition of Terms

To ensure uniformity and understanding of the terms used throughout the study,
the following definitions are provided:

**Codes:** Are labels that assign symbolic meaning to the descriptive or inferential
information compiled during a study (Miles et al., 1994, p. 71).

**Descriptive Code:** Assigns labels to data to summarize in word or short phrase-
most often a noun- the basic topic of a passage of qualitative data (Miles et al., 1994, p.
74).

**Differentiation:** Tomlinson (1999) stated, “In a differentiated classroom, the
teacher plans and carries out varied approaches to content, process, and product in
anticipation of and response to student differences in readiness, interest, and learning needs” (p. 10).

*Density:* The term refers to the number of links of a certain code to other codes within the collected data (Friese, 2014).

*Direct Instruction:* Direct instruction will be defined as Carnine et al (2000) stated: Direct Instruction is an approach to teaching. It is skills-oriented, and the teaching practices it implies are teacher-directed. It emphasizes the use of small-group, face-to-face instruction by teachers and aides using carefully articulated lessons in which cognitive skills are broken down into small units, sequenced deliberately, and taught explicitly. (p. 5-6)

*Free choice:* Is a proposal slip that students can fill out and submit to the teacher for approval. Sixty-three options of “free choice” are provided for the students to choose from.

*Groundedness:* The term refers to the many times a certain code has been used by the participants to give an example of how relevant is the code within the collected data (Friese, 2014).

*Hermeneutic Unit (HU):* a data file that stores everything you do to the data in ATLAS.ti (Friese, 2014). Since the researcher was working with internal text documents, then the HUs data files contain the actual data.

*Interest:* For a teacher to differentiate based on student’s interest means to prepare tasks for students that intrigue their curiosity for learning.
**In Vivo Code:** It’s a descriptive code that uses words or short phrases from the participants own language in the data record as codes. It’s a way to honor participant’s voice (Miles et al., 1994, p. 74).

**Learning Profile:** For a teacher to differentiate based on the learning profile of the student means to keep the learning style, the student background, and the intelligence profile in the learning process.

**Meal Menu:** A list of Breakfast, lunch, dinner, and dessert options. The total number of predetermined questions is nine (under each meal), as well as two or more enrichment activities for students (Westphal, 2013, p. 9). The questions are generated based on Bloom’s Taxonomy including different learning styles, readiness, and interest.

**Memos:** From a purely functional perspective, memos in ATLAS.ti consist of a title, a type, and some text. They can be free or linked to other memos, to codes, and to quotations (Friese, 2014).

**Methodological Triangulation:** The term refers to the merge of both types of collected data: qualitative and quantitative.

**Process Code:** Are used exclusively to connote observable and conceptual action in the data. Processes also imply actions intertwined with the dynamics of time, such as things that emerge, change, and occur in particular sequences (Miles et al., 1994, p. 75).

**Readiness:** For a teacher to differentiate based on readiness level means to prepare tasks for students at different level of difficulty.
Rubric: Is a guideline for students to follow. It provides a clear breakdown of the teacher’s expectation. Rubrics are placed in a designated area in the classroom for the students to choose from.

Tic-Tac-Toe: Tic-Tac-Toe menu is a 3X3 board. It has eight pre-determined choices and one free choice for students to select. The expectation is to solve three problems in a row or column and a free choice. The questions are generated based on Bloom’s Taxonomy including different learning styles, readiness, and interest (Westphal, 2013, p. 8).

20-50-80 Menu: Is a variation on a list menu with a total of at least eight predetermined choices. 20-50-80 contains two questions with a point value of 20, four questions with a point value of 50, and two questions with a point value of 80. Students have the freedom to choose a total point of 100 (Westphal, 2013, p.13). The questions are generated based on Bloom’s Taxonomy including different learning styles, readiness, and interest.

Theoretical Framework

Differentiation proposed by Tomlinson (2000) is defined as “attending to the learning needs of a particular student or small group of students rather than the more typically pattern of teaching the class as though all individuals in it were basically alike” (p. 4). The goal of a differentiated classroom is to maximize the individual success and growth of each student in the classroom. The nuanced interaction between how teachers differentiate their instruction via content, process, product, and how teachers differentiate according to students’ readiness, interest, and learning profile provides the conceptual framework of differentiation.
Since 1956, Dr. Benjamin Bloom promoted higher forms of thinking in education. Remembering facts and memorizing concepts were not the best strategies to actively engage students in their learning. Bloom (1956) emphasized the idea of fostering higher thinking skills by focusing on three domains of learning:

1. Cognitive: intellectual skills (knowledge)
2. Affective: development in mindsets or other emotional regions (attitude or self)
3. Psychomotor: physical skills (skills)

Bloom (1956) and his colleagues, in the education system, followed the same taxonomy biologists adopted to communicate with animals. Bloom (1956) focused on the necessity of achieving learning outcomes of any subject matter as the ultimate goal for education.

Once students develop a solid understanding of the material they will feel better about themselves and that will, in return, open new desire for learning. Thus, affective domain is satisfied, which will improve students’ psychomotor skills. The process of needs is clear in Maslow’s (1968) hierarchy of needs, which includes the following:

- Physiological needs: nutrition, water, air, shelter
- Safety needs: safety, freedom from distress, stability
- Belonging and love: networks, partner, family
- Self-esteem: self-respect, accomplishment, reputation

Bloom’s cognitive domain of learning ‘focused educators’ attention on the learning outcomes…what students should know and be able to do” (Woo, 1999, p. 22).

Later, Bloom (1956) published his “Taxonomy of Educational Objectives and Cognitive
Domain” (Bloom, 1956), known as Bloom’s taxonomy. Bloom’s taxonomy gave educators a defined framework for achieving desired educational outcomes through a hierarchy organized according to cognitive difficulty. Bloom (1956) described his six levels as the following:

Level I: Knowledge. It is the level that is focused on recalling, recollecting, and retrieving saved information.

Level II: Comprehension. This level entails the ability to understand the material. “The emphasis is on the ability to grasp the meaning and the intent of the material” (p. 89).

Level III: Application. It involves the ability to use previous information to solve and demonstrate the understanding of knowledge. “A demonstration of comprehension shows that a student can use an abstraction when the use is specified. A demonstration of application shows that he/she will use it correctly, given an appropriate situation, without prompting” (p.120).

Level IV: Analysis. This level encompasses the learner forming, classifying, and organizing relationships of the material in a structured arrangement. Examples include the differences between facts and theories, and recognizing rituals, habits, shapes, patterns, and etc.

Level V: Synthesis. This level requires taking all five preceding levels to devise new concepts, predictions, conclusions, and hypotheses. It is “…the putting together of elements and parts so as to form new whole…the student must draw upon elements from many sources and put these together into a structure or pattern not clearly there before” (p. 162).
**Level VI: Evaluation.** This is the highest level in the taxonomy and it is defined as: “the making of judgments about material. It involves the use of criteria as well as standards” (p. 185).

Similarly, Tomlinson (2003) argued that learning takes place only when students experience instruction at a level of difficulty that is appropriately challenging and attainable. Teachers cannot assume that learning is actually happening without addressing individual needs. Tomlinson et al. (2000) stated: “when an entire class moves forward to study new skills and concepts without any individual adjustments in time or support, some students are doomed to fail” (p. 4). Measuring student’s progress against a predetermined benchmark is sometimes relative, however, understanding where a student’s learning is relative to a benchmark can be useful. In a differentiated classroom teachers will monitor individual growth and development and assess students’ success based on individual growth.

There is nothing fundamentally negative or positive about instructional strategies. For the most part, they are simply methods to deliver content to students. Yet, some methods are better suited to reaching one type of goal than another. Teachers can use any method they please to deliver content; however, methods can be used well or poorly. In addition, all methods can be used in ways to either ignore students’ differences, or to appropriately respond to the multiple existing differences. According to Gregory et al. (2013):

There are seven categories, which capture student differences:

1. **Differences in learning:** These seem to be evident and categorized by multiple researchers as well as psychologists who help the teacher and student know
how they can best access and process information and deal with their approach and preferences to learning.

2. *Differences in sensory-based learning:* Students have preferences based on how they best process information through their senses. Sensory source preference includes auditory, visual, and tactile/kinesthetic. Teachers who provide a multisensory classroom will be a step ahead and will satisfy more learners by offering a variety of modes of processing and learning.

3. *Differences in thinking:* A theory of thinking styles is based on two variables: the way we view the world in an abstract or concrete way, and the way we order the world in either a sequential or random order.

4. *Differences in multiple intelligences:* Children have various strengths and needs for growth in the areas of multiple intelligences. Gardner (2004, 2006) describes eight intelligences: verbal-linguistic, musical-rhythmic, logical-mathematical, spatial, bodily kinesthetic, intrapersonal, interpersonal, and naturalistic. Existential intelligence is also being explored. Educators intentionally include all intelligences over time to provide students with areas of comfort and areas of weaknesses, where they will accomplish and develop farther.

5. *Gender differences:* There are anatomical differences in boys’ and girls’ brains, and they have different needs in the learning process (Gurian, Henley, & Trueman, 2001).
6. **Cultural differences:** All students—regardless of ethnicity—have cultural differences that influence their approach to learning and their desires in classrooms.

7. **Students’ interest:** A variety of diverse experiences cause students to have different interests. (P. 861)

If teachers can approach meeting individual student differences by offering opportunities within each student’s zone of proximal development (Vygotsky, 1978), and by providing access to new ideas beyond students’ knowledge but within their reach, then learning will happen. Vygotsky (1978) explained the zone of proximal development as: “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86).

Furthermore, Byrnes (1996) asserted that instruction should always be in advance of any student’s current level of mastery. Meanwhile, information should neither be presented well above nor well below the level of mastery. He stated:

The consensus of a broad range of psychologists and brain researchers is that:

Instruction should always “be in advance” of a child’s current level of mastery. That is, teachers should teach within child’s zone of proximal development. If material is presented at or below the mastery level, there will be no growth. If presented well above the zone, children will be confused and frustrated. (p. 33)

Therefore, when designing lesson plans and classroom activities with students’ interests and readiness level in mind will ensure that each student in classroom has the
opportunity to contribute to class discussion and to feel comfortable sharing their opinion.

As educators, we measure students’ comprehension by their active engagement in classroom discussion. Often, when a student is introverted, the material discussed is either extremely hard or overly simple to capture their attention. Small and Lin (2010) argued the need for approaching differences that dwell among students by instruction via a sound knowledge of the student’s zone of proximal development. They stated:

Teachers are not using educational time wisely if they either are teaching beyond the student’s zone of proximal development or are providing instruction on material the students already can handle independently. Although other students in the class might be progressing, the student operating outside his or her zone of proximal development is often not benefiting from the instruction. (p. 2)

Therefore, Brain research appears to confirm that the need for “relaxed alertness” and “moderate challenge” is beneficial for students’ engagement inside classrooms. It is essential that teachers provide learning experiences that are neither boring nor apprehensive for the learners.

Though the Curriculum Principle of the NCTM Principles and Standards for School Mathematics (2000) stated, “A curriculum is more than a collection of activities, it must be coherent, focused on important mathematics, and well-articulated across grades” (p. 14), mathematics textbooks continue to be uninteresting in nature. Mathematics textbooks tend to focus on procedural and direct instructional knowledge rather than the comprehension of knowledge based on students’ level of competency and
differences. Many students do not have skills to handle such demanding and monotonous textbooks. More specifically, the apparent image of Algebra is that it is a demanding and extremely abstract course that lacks connection to daily real world situations in the lives of students.

After 13 years in teaching, I still find most students struggling with mathematics, more specifically, Algebra II. The reason relates to the abstract nature of the subject and the lack of foundational comprehension. Therefore, it is important for teachers to help all students maximize their growth and learning by trying new instructional strategies as tools to support students’ success. According to Prince and Howard (2002), children need not only to survive but also to thrive. In a differentiated instruction classroom, the fear is decreased and children are free to take risks in their learning. By designing lessons that are appropriate for all learners’ readiness, interest, and learning profiles, teachers will empower their students and maximize their growth and learning experiences. Tomlinson (2001) stated: “Differentiation calls on a teacher to realize that classrooms must be places where teachers pursue our best understandings of teaching and learning every day, and also to recall daily that no practice is truly best practice unless it works for the individual learner” (p. 17).

As stated earlier, most teachers adapt and adjust their teaching to their students’ needs; but expert teachers understand the need to learn more about the subject taught and their learners’ “particularness” in classrooms and attend to it, to maximize student growth and individual success. As a result, this research study will provide an opportunity for the researcher to implement and observe outcomes of differentiated instruction in her classroom. Therefore, this study could provide some means of applying mathematics
conceptual knowledge, which improves the experience of students. Adopting differentiation in a mathematics classroom to an enhanced acquisition of mathematical knowledge.

There are numerous ways of applying differentiation in any given classroom. According to Tomlinson (2000), differentiation happens based on three main concepts: Content, Process, and Procedure. Differentiated instruction is depicted in Figure 1 below. Differentiation will happen according to: Students’ readiness, interest, and learning profiles.

![Diagram of Differentiation of Instruction](image_url)
There are numerous ways to differentiate within a classroom. However, for the purpose of this study, differentiation will be defined as Tomlinson (1999) stated: “In a differentiated classroom, the teacher plans and carries out varied approaches to content, process, and product in anticipation of and response to student differences in readiness, interest, and learning needs” (p. 10). Throughout this research, the researcher will be differentiating her instruction based on all three domains: content, process, and product according to student’s readiness level, interest, and learning profile. Some strategies the researcher will be using are: tiered lesson plans, tiered products, varied questioning activities, small group instruction, varied supplementary materials, and the theory of multiple intelligences.

It is important to keep in mind that further research is needed to determine if differentiated instruction increases the level of competency in mathematics education. While some educators still view differentiation as a time consuming process to prepare for class, others see it as a necessity to maximizing the learning experience for all students. The outcomes of this study could be potentially considered to reform education.

**Overview of Future Chapters**

The remainder of this study is divided into four major chapters. Chapter II consists of the literature review which discusses prior theory and practice results for implementing differentiated instruction inside the classroom. The focus of the chapter will be mainly on scholarly works available, which highlight benefits and challenges of differentiated instruction in classrooms.
Chapter III is dedicated to the methodology used in this study. In addition to the detailed explanation of the different methods of differentiation, and the role of the teacher inside the classroom, this chapter focuses on the mixed method design included in this research. It discusses the qualitative and quantitative data collected. Detailed description and procedures for both data types are explained in this chapter.

Chapter IV is a presentation of both qualitative and quantitative data findings. The chapter recaps the tools used when collecting data and further discusses results in the subsequent chapter.

Chapter V of this research mainly focuses on results of the data analysis. It delivers the discussion on the research findings. It entails the implications for practice, limitations of the study, and further research proposed as a result of this case study.
Chapter 2

Literature Review

Introduction

This chapter serves as a summary of the scholarly research that is relevant to differentiation and how it can be implemented in the classroom. It is further divided into multiple sections. The sections are the following: Brain and social development, the different approaches to curriculum over the years, multiple intelligences, and an elaborated upon conceptual framework for differentiated instruction. The researcher will present the preceding theories and approaches to teaching and learning and discuss research available to support the various methods for approaching curriculum.

Brain and Social Development

Maslow’s (1968) hierarchy of needs: Physiological needs, safety needs, love and belonging, and self-esteem are essential for students’ success. Human beings generally progress through the hierarchy from basic to complex needs. As each step is achieved, the human being becomes less focused on that step and advances to the next level. Therefore, meeting students’ needs and creating a safe environment for all to learn should minimize stress and maximize growth.

Educators should recognize all humans have a need to be accepted and included. To support this need, students should have the chance to interact with one another and with their teacher. Thus, classrooms should foster a sense of community, safety, and inclusion. Vygotsky’s (1978) social development constructivist theory of learning, on which many of the principles of differentiation are based, discussed the following needs:

1. Social interactions (teacher to student, student to teacher) to foster learning.
2. To learn, one needs a more knowledgeable other (teacher, coach, or mentor).

3. Students will perform a task better and with more pleasure if it is within reach and they have the more knowledgeable other. (p. 251)

The social development theory is the basis for differentiated instruction. In a differentiated instruction classroom, the teacher is promoting social interactions by placing students in groups. Within groups, students interact and discuss the content material learned with their peers and their teacher. Teachers are an essential part of all groups inside classrooms because they are the facilitators of learning. Through the support and guidance teachers provide to different groups, students prosper and succeed.

Regardless of individual differences, students are still expected to master the same concepts, principles, and to be proficient in all subject areas within the constricted time frame. Helping all students succeed in their learning is an enormous challenge that requires innovative strategies to teaching and special attention to students’ interest and needs. According to Stevenson (1992),

In order for all students to experience successes that matter to them, schoolwork must accommodate individual differences of talent and development. Students are developmentally unequal. Therefore, educators must ensure that for a substantial portion of their school lives, students will be able to see their success along a variety of paths. Teachers’ expectations must reflect an understanding of differences. (p. 122)

An effective classroom is a classroom in which similarities and differences among learners is recognized and addressed. Therefore, educators realize the following: Individuals differ as learners, students should be the center of the learning process, all
learners require an engaging classroom environment to maximize growth, and learners should be competing against oneself to grow and develop.

Jensen (1995) emphasized the need for creating the right climate for the brain to learn. He offered the following as suggestions to foster a nourishing classroom environment:

1. **Identify substandard learning behaviors.** Identify areas of threats, both implied and explicit. Avoid reliance on extrinsic rewards. As much as possible, remove threats from the learning environment and introduce alternative forms of motivation, such as novelty, curiosity, positive social bonding, and relevant content.

2. **Make the learning environment a safe, relaxed environment.** Avoid calling on learners unless they volunteer. Eliminate discipline policies that work by threat, score keeping, or embarrassment. Give more time for classwork. Reduce the threat of grades by providing more frequent feedback. Make the assessments genuine and meaningful.

3. **Ensure that learners have met the following conditions:** (a) they perceive a solution is possible; (b) they have the resources to solve a problem; (c) they have control over the situation; (d) they have sufficient time to do the learning; and (e) they have the knowledge and skills to recognize and manage their own stress levels.

4. **Increase support and engagement.** Make the testing or other assessment times less stressful by encouraging partner work, allowing stretch breaks, giving
immediate successes followed by engaging complex projects and giving verbal encouragement.

5. **Give students a sense of self-worth, a feeling of importance and uniqueness.**

Teach them that they are not helpless. Help them learn to discover what areas of life can be controlled so that the “victim” mentality is never cultivated. (p. 233)

Jensen’s (1995) preceding suggestions are the framework of a differentiated classroom. Though differentiation may take different forms, in general, teachers are first pre-testing students, and based on the results of this assessment, lessons are designed to meet individuals’ interests and cognitive levels. Students are placed in a seemingly appropriate unit level to minimize the chance for becoming frustrated or bored. Creating lesson plans based on students’ strength levels, gives them the sense of having control over the situation in order to attain reasonable solutions, all of which, help create a safe environment where self-worth and feelings of uniqueness are noticeable and enhanced.

Furthermore, research has shown that the human brain is adaptive by nature, and providing a compatible environment will ensure learning. Jensen (1998) stated,

*Our brain is highly effective and adaptive. What ensures our survival is adapting and creating options. A typical classroom narrows our thinking strategies and answer options. Educators who insist on singular approaches and the ‘right answer’ are ignoring what’s kept our species around for centuries*. (p. 16)

Therefore, educators have to create a balance, which provides students with a wide variety of activities that promote a safe environment to grow and learn. Educators have to accept change in their notions of teaching. Classrooms should be active and
engaging, students should be the center of the classroom, and teachers should focus on the meaning-making approach to teaching and learning.

Creating a respectful environment for each student and the group as a whole is essential to promoting enthusiasm about learning. Students and teachers should work collaboratively to construct a sense of community where successes are celebrated and impediments are destroyed, where similarities and differences are valued and celebrated. Kaufeldt (1999) stated,

The goal is to create climate that balances low threat with evidences of challenge for a wide range of students’ interests and abilities. The environment must still have tasks, projects, displays, symbols, and clues that will instigate students’ intrinsic motivation and attract their interests, attention, and curiosity. If they feel comfortable, then they will not put barriers up and therefore will be open to possibilities of reflection and engagement. (p. 15)

Therefore, in a differentiated classroom, teachers and students are working alongside each other to acquire knowledge. Teachers and students are engaged in collaborative and reflective conversations to promote the individual growth and development. Teachers provide students with opportunities to problem solve and explore content and tasks that are substantial and meaningful.

According to Tomlinson (1999), teachers in differentiated classrooms are always accommodating their students’ needs by using different instructional strategies and becoming partners with their students. Students in a differentiated classroom might work in small groups that are randomly selected by the teacher or by the students themselves. At other times, they may work with other learners who are at the same achievement level.
The Different Approaches to Curriculum

Much research has been conducted to describe an effective teaching design. The education field has been struggling to find a seamless formula for teachers to adopt to increase students’ performance and retention of content. Ralph Tyler (1949), Basic Principles of Curriculum and Instruction, advocated the approach of focusing on instruction. The following questions compose Tyler’s (1949) rationale, which guide curriculum designers’ decisions:

- What educational purposes should the school seek to attain? (Loc. 155)
- How can learning experiences be selected that are likely to be useful in attaining these objectives? (Loc. 971)
- How can learning experiences be organized for effective instruction? (Loc. 1249)
- How can the effectiveness of learning experiences be evaluated? (Loc. 1583)

Tyler’s Rationale first focused on learning the desired outcomes, followed by plans and experiences teachers provide to support these learning outcomes. The learning experiences should be carefully organized in a manner to promote effective acquisition of knowledge. Teaching is the means to reach a desired end; therefore, the clarity of learning objectives and evidence to show that learning occurred are mandatory steps in designing a curriculum.

As educators we understand that no two students enter a classroom with identical aptitudes, skills, and needs. Current student populations are becoming increasingly academically diverse. Varied student backgrounds, languages, interests, learning profiles, and readiness all contribute to a huge variance within a single classroom.
Educators, who are continuously teaching their students the same lessons over the years using an identical method, are not taking into account different learning styles, different interests, and variances that dwell among learners. Teachers have to be cognizant about their students. According to Vygotsky (as cited in Tomlinson, 2001):

We know that learning happens best when a learning experience pushes the learner slightly beyond his or her independent level. When a student continues work on understandings and skills already mastered, little if student’s current point of mastery, frustration results and learning does not. (p. 8)

Educators should recognize that the traditional classroom instruction approach does not meet students’ needs and readiness levels. Individualizing instruction is a much more effective approach to teaching. Providing the appropriate challenge for each student at an appropriate level enable students to thrive. Because educators know their students and the way they process information, they teach in a way that best help students be more engaged.

Many researchers have viewed education as a continuous process that involves students’ experiences and their participation viewed education as:

Education is an active process. It involves the active efforts of learner himself. In general, the learner learns only those things, which he does. If the school situations deal with matters of interest to the learner he will actively participate in them and thus learn to deal effectively with these situations. (Loc. 262)

Therefore increasing effectiveness of learning stems from students’ interests and engagement in the acquired content. It is important for educators to investigate students’ interests before embarking on teaching a topic. When educators factor their students’
interests into their teaching, students’ comprehension increases and their growth and interests maximize.

Brain research emphasized that the human brain learns by grasping meaningful information. Grasping meaningful information does not happen without an established comprehension of knowledge from previous experiences. Integrating the curriculum into students’ lives and carefully making connections between students’ lives and teaching and learning is not an innovative concept. Progressive educators like Dewey (1938) argued strongly that meaningful learning transpires from various experiences and one’s interpretation of an experience is merely contextual. Therefore, knowing students’ background knowledge and building upon their skills will help with the retention of newly presented knowledge. According to Callahan (1999):

A curriculum should be structured around big ideas. If teachers are to provide different levels of instruction and address varying learner profiles, they must organize the curriculum around the concepts, principles, and generalizations of the disciplines. Standards should be the core of generating those ideas and the particular examples of the ideas, rather than as disconnected segments of instruction. (p. 6)

As Callahan (1999) explained, curriculum should be rich, engaging, focused on learning goals of each unit, coherent to students, and clear in terms of what students should know, understand, and do as a result of mastering content. Curriculum should have activities and discussions that drive students to a higher level thinking to be able to handle complex problems and content.
Similarly, without a coherent curriculum, information is worthless. Much research has been done to enforce the need to connecting new knowledge to pre-existing knowledge. Wolfe (2001) described the brain creating meaning from past experiences:

Consider students in a classroom confronted with information that does not match anything they have previously stored. Their brains look for an appropriate network to help them make sense or meaning of this information. If nothing can be found, the information is discarded as meaningless. (p. 86)

Therefore, curriculum has to be coherent and connected to students’ lives. When teachers provide students with choices of activities and materials, students explore key ideas and skills in ways that connect with their own inclinations, experiences, and desires. Thus, the connection between students’ background knowledge and acquired material to promote growth in learning and appreciation of knowledge.

Curriculum experts advocate for a comprehensive design for any curriculum. A convenient instrument for aligning a comprehensive curriculum is curriculum mapping. Wiggins and McTighe (2011) focused on backward design, where teachers have to focus their instruction on the outcome and the purpose of the curriculum. Implying that a teacher can start and end the process with evaluations. Wiggins and McTighe (2011) looked at teaching as: “means to an end, and planning precedes teaching” (p. 7). They stated,

The key to Understanding By Design is to understand that, just like a coach or a trainer, we must design backward from complex long-term performance where content is used, not from discrete topics or skills where content need only be recalled. Such performance lies at the heart of genuine expertise. (p. 7)
Therefore, educators should think of the big picture of the units they are planning to teach, as they plan their lessons. Throwing multiple concepts on students and hoping some concepts would adhere to their memory will not triumph. However, identifying specific learning outcomes first followed by creating a clear instructional path would support the achievement of those outcomes.

Other curriculum experts like Jacobs (1997) focused on 21st century approaches to curriculum. Jacobs created a “calendar based” model for mapping the curriculum that stressed both micro (classroom level) and macro (school of district level) mapping (p. 3). There are various benefits to mapping the curriculum, some of which include connecting material taught to the overall curriculum, influencing educators to be mindful of the continuum of the subject matter, and creating transparency in learning goals.

The first benefit of mapping the curriculum is connecting concepts and skills taught in classrooms to the objectives of the curriculum. Subsequently, based on formative and summative evaluations, curriculum alignment might be altered. Tomlinson (2000) discussed motivating students and keeping them engaged in content explained. Therefore, she looked at curriculum mapping as an opportunity to help teachers challenge different learners inside their classrooms. According to Tomlinson, students whose skills were under-challenged showed low connection through learning activities and a decline in attentiveness. Equally important, students whose skills were lacking for the level of challenge showed both low accomplishment and a plummeting of self-worth. Therefore, when students are
frustrated due to curriculum that might be either excessively difficult or easy for them, learning will not occur.

The second benefit for mapping the curriculum is encouraging educators to be mindful of the continuum of their subject matter. Chiarelott (2006) reviewed curriculum mapping as a valuable instrument for teachers to consider using in their teaching. He stated,

Curriculum mapping is a valuable tool for educators who want to analyze the discrepancy between the planned, advertised curriculum and the curriculum actually being delivered by teachers in the classroom. (p. 9)

When teachers map the curriculum, the existing curriculum design will help determine many variables hidden in the content area being taught. The benefit of mapping the curriculum is evident in articulating scope and sequence, integration and continuity, and horizontal verses vertical articulation of content will all be addressed. Thus, the likelihood of altering goals, instructional strategies, and sometimes content can be met.

A third benefit to mapping the curriculum is creating transparency of learning objectives for all educators in the district to see and follow. Therefore, the frequently occurring content can be eliminated, and pioneering content can be emphasized. It is important for teachers to look through the material and analyze what content to be explained to certain group of students and what content to be eliminated. Gregory et al. (2013) stated,

Determine how the information can best be taught to this particular group or groups of students. Weed through the resources available, and find the
materials that will best meet the needs of these students. Determine how students will be grouped and what tasks will be assigned to challenge them at the appropriate levels. (p. 488)

Teachers ought to design a curriculum that accelerates the cognitive level of students and formulates foundation, which supports learners’ comprehensive experiences. Teachers should view states’ benchmarks as goals, not limitations. Thus, aligning benchmarks across grade levels by mapping the curriculum allows teachers to compact the curriculum and focus on best practices and new approaches to teaching.

Integrating the curriculum into students’ lives is not a new idea. Throughout the years, much research has been conducted to associate students’ meaningful learning with instructional strategies. Research has established facts about the existence of a strong alignment between contextual teaching and learning (relating subject matter to real life situations) and students’ acquisition of knowledge. Chiarelott (2006) described contextual teaching and learning as a system that connects various but related approaches to teaching that encompasses the following characteristics:

- Connecting content to learners’ experiences.
- Engaging students in active learning
- Enabling students to have opportunities to direct their own learning.
- Encouraging the construction of personal meanings from individual and collective experiences.
• Assessing the attainment of outcomes within an authentic situation and allowing for the interpretation of multiple meanings from a single experience
• Identifying contexts that are appropriate developmentally to the learner.

The characteristics listed above are the core for contextual teaching and learning because they provide teachers with tools to relate content taught in class to real world problems. In addition, they highlight the correlation between knowledge and its application. Therefore, from a student perspective, content does not seem so isolated anymore; content is the key for better construction of knowledge and more effective teaching.

Moreover, in the *Hidden Curriculum*, Blanchard (2014) emphasized 21st century education calls for critical thinking, collaboration, creativity, building characters, and communication. Therefore, learning to compute, and demonstrating mastery of material by achieving high grades on written assessments, is not enough.

As educators, we have to instill the sense of curiosity in students’ minds, get them engaged, and have them demonstrate their learning based on their interests in life. Gregory et al. (2013) stated,

Yet for years we have planned ‘The Lesson’ and taught it to all, knowing that we were boring some and losing others because they were not ready for that learning. Still, we expect students to adjust to the learning when the learning should really adjust to the learners. Adjustments should be based on sound knowledge of the
learners. This includes what they know already, can do, like, are like, need, and prefer. (p. 364)

Teachers understand students will continue to be ill served if they do not adjust their teaching to meet students’ needs. Unfortunately, some teachers do not know how a classroom would look if they respond to our learners’ interests, learning profiles, and readiness levels. In reality, however, all students have the right to enthusiastic teachers who are ready to meet them where they are and help them move forward. Therefore, adjustments should be made to address students’ needs and interests in order for our students to learn.

There is a need for teachers to engage students in their learning and to encourage their reasoning. Many educators discuss that the best learning takes place when students are engaged. The National Council of Teachers of Mathematics (2014) examined the need to engage students in their learning to maximize comprehension and analysis of knowledge. As stated in Principles to Actions: “mathematics lesson should be centered on engaging students in solving and discussing tasks that promote reasoning and problem solving” (p. 10).

Teachers who hold this principle of planning lessons centered on engaging students promote interactions and active learning which shift the focus from procedural to conceptual understanding of the material. This in turn, fosters maximum comprehension growth and development.

Leinwand (2009) examined how educators agree that the goal of teaching students should be to ensure that all recognize and are capable of applying mathematics as a direct result of their school experiences. However, we are falling short of this goal. In his
opinion, the answer for better teaching is: “instruction” (p. 9). The instruction process consists of: actions, plans, and instructional strategies, daily interactions between teachers and students and among students in classrooms. All of the proceedings are what determines how well and how much students will learn.

The latest research in the field of education that addresses this shift in instructional strategies is differentiated instruction. Gregory et al. (2013) detailed: “Differentiation is not a set of tools, but a belief system or mindset that educators embrace to meet the unique needs of every learner. (p. 373)

As educators, we know that not all students learn the same thing the same way in the same time; therefore, the need to consider each child’s learning environment, readiness, and interest is necessary. Gregory et al. (2013) stated:

For many decades, educators used a bell curve to rank students. They did not expect everyone to succeed. It was more the norm to ‘teach, test, and hope for the best.’ Today, however, we do expect that all students will learn to their full potential and that all teachers will find a way to enable each individual to be successful. (p. 454)

We live in a diverse world of high responsibility. Educators are expected to provide opportunities for students to exercise and advance their skills. The bell curve model for teaching does not pertain to 21st century education. Not all students learn the same way on the same day. Therefore, keeping students’ interests, learning profiles, and readiness in mind helps all learners achieve.
Multiple Intelligences

It is equally significant for teachers and students to realize the importance of addressing multiple learners and their different intelligences inside the classroom. Learners should be given the chance to reach their full potential. Differentiated instruction is one tool to address multiple intelligences, which are embedded among different students in the same classroom. In a differentiated classroom, one lesson becomes multiple lessons to meet the needs of the multiple learners. Research conducted by Dunn, Griggs, Olsen, Beasley, and Gormann (1995) discussed meeting students’ intelligences will improve students’ achievement inside classrooms. Similarly to Dunn et al., Beck (2001) discussed the need for teachers to design lesson plans that match students’ natural and distinctive abilities in order for students to learn better. He stated:

As teachers become aware of their students’ learning style preferences, they are more likely to make an effort to accommodate these differences. This effort is likely to produce more effective instruction and higher student achievement for several reasons: First, the students are more apt to respond favorably to the subject matter if it is presented in a manner that accommodates their learning preference. Second, in addition to higher achievement levels, the students’ positive attitudes are likely to lessen the amount of indifference and behavioral problems. Third, when teachers employ a variety of strategies to address various learning styles, they broaden their own instructional versatility and creativity. (p. 4)

Teachers aspire to be effective educators and understanding differences among students is a central process for attaining this desire. By knowing students in
classrooms and presenting content material to them according to their different styles of learning, students develop an appreciation for the subject; which increases their engagement and comprehension of the material (Tomlinson, 2000).

Gardner first introduced his theory of multiple intelligences in early 1980s. Gardner’s theory (2006) discussed the differences in which people acquire a certain intelligence and how it defines how they learn and interrelate best with other individuals. Gardner (2006) reviewed the first eight intelligences as follows:

1. *Linguistic Intelligence*: The understanding of phonology, syntax, and semantics of language, and its pragmatic uses to convince others of a course of action, help one to remember information, explain or communicate knowledge, or reflect upon language itself.

2. *Bodily-Kinesthetic Intelligence*: The ability to control one’s bodily motions and the capacity to handle objects skillfully.

3. *Spatial Intelligence*: The ability to perceive the visual world accurately, to perform transformations and modifications upon one’s initial perceptions, and to be able to re-create aspects of one’s visual experience.

4. *Musical Intelligence*: The ability to understand and express components of music, including melodic and rhythmic patterns through figural or intuitive means (the natural musician) or through formal analytical means (the professional musician).

5. *Logical Mathematical Intelligence*: The understanding and use of logical structures, including patterns and relationships, and statements
and propositions, through experimentation, qualification, conceptualization, and classification.

6. Intrapersonal Intelligence: The ability to access one’s emotional life through awareness of inner moods, intentions, motivations, potentials, temperaments, and desires, and the capacity to symbolize these inner experiences, and to apply these understandings to help one’s own life.

7. Interpersonal Intelligence: The ability to notice and make distinctions among other individuals with respect to moods, temperaments, motivations, intentions, and to use this information in pragmatic ways, such as to persuade, influence, manipulate, mediate, or counsel individuals or groups of individuals towards some purpose.

8. Naturalist Intelligence: The ability to recognize and classify the numerous species of flora and fauna in one’s environment (as well as natural phenomena such as mountains and clouds), and the ability to care for tame, or interact subtly with living creatures, or with whole ecosystems. (p. 13–14)

In a differentiated classroom, teachers may consider multiple intelligences when designing their lesson plans. When a lesson or an activity is designed to match the intrinsic ability of students, students will embrace the material, apply the acquired skills acquired, and greatly improve the performance outcomes.

Furthermore, The National Association of Secondary School Principals’ *Breaking Ranks II: Strategies for Leading High School Reform* (2004) encourages emphasis on essential learning, rather than coverage, where teachers should be connecting with students as means to increase student achievement, classroom
adaptations for students’ learning differences, and flexible use of classroom time to encourage application of instructional strategies, which are consistent with how students learn best. Accordingly, the challenge for teachers is not only having students in heterogeneous classrooms, but also dealing with those students’ differences at different levels. Judy Willis (2006), a licensed neurologist and middle school teacher, noted: “the best-remembered information is learned through multiple and varied exposures followed by authentic use of the knowledge” (p. 30).

Therefore, it is important for teachers to vary their instruction and address the talents and the intelligence profiles of their students. In a differentiated classroom, teachers are constantly adjusting their teaching styles to match students’ intelligences and applications of knowledge.

**Differentiated Instruction**

While the concept of differentiated instruction should be vague for some teachers, the intention of differentiation should not be. Educators aim to maximize students’ growth and individual success regardless of their field of teaching. The claim to differentiated instruction, as stated by Tomlinson and Demirsky (2000), in the context of education, is:

… a teacher who is differentiating understands a student's needs to express humor, or work with a group, or have additional teaching on a particular skill, or delve more deeply into a particular topic, or have guided help with a reading passage—and the teacher responds actively and positively to that need. (p. 4)

Consequently, the objective of differentiated instruction is to address the learning needs of each student in the classroom. Allowing students to work in groups of
compatible levels, or allowing students to work in groups of mixed abilities, draws upon the strength of individuals in the group, rather than teaching the whole class as though all individuals are essentially identical.

Teachers can create differentiated and personalized education in many ways. However, Tomlinson (2000) insisted on three strands of the curriculum that can be differentiated: Content, Process, and Product. According to Tomlinson (2000), teachers can differentiate based on content which includes both what the teacher plans for students to learn and how students gain access to desired knowledge, understanding, and skills (p.7).

According to Tomlinson (2000), some of the ways a teacher might differentiate access to Content include:

- Using math manipulatives with some, but not all, learners to help students understand a new idea.
- Using texts or novels at more than one reading level.
- Presenting information through both whole-to-part and part-to-whole approaches.
- Using a variety of reading-buddy arrangements to support and challenge students working with text material.
- Re-teaching students who need another demonstration, or exempting students who already demonstrate mastery from reading a chapter or from sitting through a re-teaching session.
- Using texts, computer programs, tape recorders, and videos as a variety of conveying key concepts to varied learners. (p. 8)
Teachers should recognize what content students need to have solid foundations in, and what skills they need to develop to master certain content. What is likely to be affected in a differentiated classroom is how students access facts, concepts, principles, and materials to represent the knowledge. The content of a subject is not going to change, but the method of delivery is distinctive in a differentiated instruction classroom.

A teacher can also differentiate the \textit{Process} of how students come to understand and make sense of the presented material. Tomlinson (2000) explained the synonym for process is \textit{activity}:

A teacher can differentiate an activity or process by, for example, providing varied options at differing levels of difficulty or based on different student interests. A teacher can give students choices but how they express what they learn during a research exercise –providing options, for example, of creating a political cartoon, writing a letter to the editor, or making a diagram as a way of expressing what they understand about the topic discussed. (p. 8)

Teachers can be very creative with the way they ask their students to present their understanding of the discussed material. By providing learners choices to express their comprehension of a certain topic, learners are engaged, enthusiastic, and motivated throughout the activities that are distinctly focused on the learning objective for the lesson.

Similarly, teachers can differentiate in terms of \textit{Product}. The term product indicates what students can demonstrate as a result of a long study. Tomlinson (2000) discussed products can be an exhibition of solutions to real-world problems, portfolio of a
student, an end of the year project, or a complex paper. Among the ways to differentiate products, Tomlinson (2000) supported the following guidelines:

- Allow students to help design products around essential learning goals.
- Encourage students to express what they have learned in varied ways.
- Allow for varied working arrangements.
- Provide or encourage use of varied types of resources in preparing products.
- Provide product assignments at varying degrees of difficulty to match student readiness.
- Use a wide variety of kinds of assessments.
- Work with students to develop rubrics of quality that allow for demonstration of both whole-class and individual goals. (p. 9)

When teachers are differentiating products, they are provoking students to rethink what they have learned throughout the course, apply what they have learned, expand their comprehension of the material, and use their skills and critical thinking to produce a creative result. An end of a unit project, a portfolio of students’ progress, and an exhibition of higher thinking skills activities are only a few examples of differentiated products.

Tomlinson (2000) explained students might vary in at least three different ways: readiness level, interest, and learning profile. Tomlinson’s research shows students are more successful when they are taught based on their own readiness levels, interests, and learning profiles. Lessons designed based on student readiness level meet the needs of all students inside the classroom: the high, the medium, and the low.
It is critical for teachers to be cognizant about the flexibility of the readiness level for any given student, at any given time, with any given topic. Tomlinson (2000) discussed readiness as the student’s entry point relative to a particular understanding or skill:

To differentiate in response to student readiness, a teacher constructs tasks or provides learning choices at different levels of difficulty. Some ways in which teachers can adjust for readiness include:

- Adjusting the degree of difficulty of a task to provide an appropriate level of challenge.
- Adding or removing teacher or peer coaching, use of manipulatives, or presence or absence of models for a task.
- Varying direct instruction by small group need. (pp. 9–10)

Teachers can assess students’ readiness for a topic by giving them a pre-assessment. Based on the result of the pre-assessment, students can be grouped either in groups of similar abilities or groups of different abilities. Teachers can use multiple instructional strategies to design lessons to match students’ readiness levels. By providing various organizers, supplementary materials, anchor activities, and multiple intelligences centers, teachers create more personalized and responsive classrooms. Inside these classrooms, students are motivated to learn and excel.

A lesson designed based on student interest will give students choice in how they learn material. Based on this, students might be grouped based on their interest, their choice, the teacher’s choice, or randomly sometimes. Students might be given the same assignment; however, the demonstration of their knowledge of the concept will be
different. The teacher can regulate choices by giving the class a chart of choices students

Tomlinson (2000) stated:

To differentiate in response to student interest, a teacher aligns key skills and
material for understanding from a curriculum segment with topics or pursuits that
intrigue students. . . . Some ways in which teachers can differentiate in response
to student interest include:

- Providing a variety of venues for student exploration of a topic or
  expression of learning.
- Providing broad access to a wide range of materials and technologies.
- Giving the student the choice of tasks and products, including
  student-designed options. (p. 10)

Teachers can differentiate their instruction based on students’ interests using
different strategies: tiered lesson plans, tiered centers, small group instruction, or
even allowing students to independently work on a topic of interest that relates to
the learning goals of the unit.

A lesson designed based on the learning profile of students would consider the
way students learn and process information based on learning style, gender, background,
and intelligence inclination. Tomlinson (2000) stated,

To differentiate in response to student learning profile, a teacher addresses
learning styles, student talent, or intelligence profiles. Some ways in which
teachers can differentiate in response to student learning profile include:

- Presenting information through auditory, visual, and kinesthetic modes.
• Encouraging students to explore information and ideas through auditory, visual, and kinesthetic modes.

• Allowing students to work alone or with peers.

• Ensuring a choice of competitive, cooperative, and independent learning experiences.

• Providing authentic learning opportunities in various intelligence or talent areas. (p. 11)

Teachers differentiating their instruction based on the learning profile of students, use varied questioning strategies, form varied interest groups, design different interest centers, assign different homework problems, and allow various journal entries.

Differentiated classrooms are mostly student-centered (Tomlinson, 1999). Tomlinson (2000) urges teachers to create student-centered classrooms, where students are given a choice. Allowing students to take part in their learning process is a vital role in helping them apply their knowledge to a much-complicated situation. By giving students choice in their learning, they will develop a skill in being decision makers and independent rather than passive learners. This sense of independence will help students design products based on their vision rather than an imposed vision from the teacher. Meanwhile, students will realize they cannot produce without learning the content necessary for achieving their goals. Westphal (2013) argued the need for giving students choice for many reasons:

• Choice is the one option that meets all students’ needs.

• Choice gives the students a greater sense of independence.
Choice strengthens students’ focus on the required content. (p. 4-5)

Teachers in differentiated classrooms provide guidance and help students develop skills of making good choices while allowing them to develop their independence. Though students might gravitate to a fancy title as their choice, they still need guidance and detailed descriptions of the different options. The skill of identifying an appropriate choice stems from starting with a small-predetermined number of choices with a detailed procedure and well explained expectations. This means when a teacher explains different options, a sense of enthusiasm and excitement should be present in all options. The focus should be on the product, not necessarily the process.

Direct Instruction is unlike Differentiated Instruction in the sense that the teacher is the center of knowledge and the governor of consequence and product. In Direct Instruction classrooms, the teacher carefully orchestrates lessons where hardly anything is left to chance. In a direct instruction classroom, the teacher focuses on systematic learning, procedures, categories, and methodology of approaching problems. Engelmann et al. (1988) stated,

The assumptions underlying the direct instruction model are: (a) all children can be taught; (b) the learning of the basic skills and their applications in higher-order skill is essential to intelligent behavior and should be the main focus of a compensatory education program; and (c) the disadvantaged must be taught at a faster rate than typically occurs if they are to catch up with their middle-class peers. Two major rules govern the selection of features in this model. The first
rule is: Teach more in less time. The second rule is: Control the details of what happens. (p. 303)

Teachers who are making a difference in their students’ lives do not expect effective teaching (teaching for all) to surface within a direct instruction classroom. Effective teachers know learners are different and that doing more is not necessarily challenging learners, as there are great teachable moments when details and outcomes are not calculated.

The goal of most schools, as they exist currently, is to bring everyone to “grade-level,” or to emphasize that all students will master a prescribed set of skills within a precise length of time. Then, teachers apply some standardized measure assessment on all students to quantify their progress against a set standard. While this process is a reflection of Direct Instruction, it is sometimes appropriate in the sense of measuring a child’s learning to a relative benchmark. However, when an entire class moves forward to learning a new concept without any individual attention or modification in time and support, some students might be destined to fail. Ayers (1993) uses a great metaphor for a classroom in which bridges are constructed between children and their learning:

Bridge building requires someone to lay the first plank. Schools are often structured round the notion that the child should lay the first, the second, and virtually every plank after that. This is defeating for many youngsters. It seems clear enough to me that the teacher must be the architect and the contractor who builds the bridge. She must know the child in order to know where to put the first plank. She must also know the world, have a broad sense of where the bridge is headed, and have confidence that she and the
students together can get there. And she must stay in touch with the child as the bridge takes shape. (p. 77)

The bridge metaphor is like the general observation you get from a classroom that is being taught using a direct instruction method. Teachers throw out the planks for students and wait for them to build their bridges in the same way, with the same tools. This approach to teaching and learning differs from a differentiated classroom, where teachers are the architects and the contractors helping each individual child build the bridge to his/her own specifications and needs.

Furthermore, in a direct instruction classroom, everything is taught through demonstration and action, until it is fully understood, and each child applies concepts and uses them on a provided assessment at the end of a chapter. Finally, every concept is reviewed thoroughly to ensure mastery. All is organized with the slightest regard for students, their talents, needs, and learning styles. Carnine et al. (2004) stated:

Direct Instruction is an approach to teaching. It is skills-oriented, and the teaching practices it implies are teacher-directed. It emphasizes the use of small-group, face-to-face instruction by teachers and aides using carefully articulated lessons in which cognitive skills are broken down into small units, sequenced deliberately, and taught explicitly. (p. 5-6)

For so many years, teachers, especially in the mathematics field, have been teaching mathematics on the basis of skill acquisitions. Teachers would prescribe a set of skills, and students would transcribe and practice those skills. Working on daily homework assignments and multiple assessments follows the transcription of lecture notes.
Though educators realize how diverse a classroom population is, and it seems only reasonable to address the diversity in classrooms by a greater diversity in instructional strategies, in direct instruction classrooms, a script is given to all students regardless of their needs, interests, and learning profiles. This model of teaching is especially true in mathematics classrooms. Leinwand (2009) discussed “students simply do not retain for long what they learn by imitations from lectures, work-sheets, or routine homework. Presentations and repetition help students do well on standardized tests and lower-order skills, but they are generally ineffective as teaching strategy for long-term learning, for high order thinking, and for versatile problem solving”. (p. 3). Our traditional model of teaching might be working for some students; however, most students are graduating with math anxiety and average if not mediocre test scores.

Research has been done to further explain differences in how mathematics teachers in Germany, the United States, and Japan culturally differ in teaching mathematics. Leinwand (2009) stated:

In the United States and Germany, the focus was on skill acquisition and typical class proceeded as follows:

- The teacher instructs students in a concept or skill.
- The teacher solves example problems with the class.
- The students practice on their own while the teacher assists individual students.

Interestingly, in Japan, one finds a very different cultural script—not necessary a better script, but certainly different. In this case the focus was understanding and the typical class unfolded this way:
• The teacher poses a complex, though-provoking problem.
• Students struggle with the problem.
• Various students present ideas or solutions to the class.
• The class discusses the various solution methods.
• The teacher summarizes the class’ conclusions.
• The students practice similar problems. (p. 3)

There is a significant difference in the way teachers implement their instructional strategies in different classrooms. There are mathematics educators who continue to follow this direct instruction method of teaching, while some are realizing that a change is needed to enhance growth and development of learners. This predicament in our education system can be easily fixed by training teachers to teach differently. Fortunately, the content of mathematics is universal; therefore, a shift in the instructional strategy of how educators plan their lessons, implement their plans, and assess the comprehension of learners might have a great impact on mathematics education.

In summary, classrooms continue to be messy and intricate environment and teaching is predictably chaotic and complex. Teachers know too much about their students to ignore their differences and or to pretend these differences are insignificant. Educators’ excessive knowledge about teaching prevents them from assuming that learning can happen naturally in an original format. Students with very advanced skills are still sitting near students who are struggling to understand and they are all taught the same lesson as if they are at an identical level. Throughout the years, we have learned, researched, and employed many different instructional strategies in our teaching. Some educators feel comfortable with differentiated instruction, while others refused to even
attempt trying new strategies. As educators, we realize the importance of personalized education to help students reach their maximum potential and enhance their knowledge. Recently, few educators are embracing this trend in education: Differentiated Instruction.

The aim of this literature review was to paint a portrait of a thematic perspective of education and its endless transformation over the years. Through the exposure of brain research, multiple intelligences, curriculum designs, direct instruction, and differentiated instruction, educators might have an extra tool in their toolbox to use inside classrooms. Educators are always seeking effective teaching methods, especially in mathematics’ classrooms where they are trying to accommodate academic diversity. Effective teaching will transpire when educators help learners think, reason, and solve problems. In an effort to make the portrait more vibrant, the conceptual framework and the understanding of basic differentiated instructional strategies will outline this research design.
Chapter 3

Research Design and Design Methods

Introduction

After getting the IRB approval, the study took place over the spring semester of the 2015–2016 academic year. A convergent parallel design was used to collect data from 30 tenth-grade students randomly placed in two sections of Algebra II classes, Block A and Block C (See Appendix A). The convergent parallel design will dictate the collection of both quantitative and quantitative data simultaneously followed by analyzing each type separately to check if results will converge and support the findings of each. The two sections A and C were divided into three or four sub-groups based on the students’ readiness level. The decision of students’ readiness level was established based on students’ performance on teacher and book-designed pre-assessments; which covered various units during the semester. The pre-assessment for each unit was designed to meet the Enduring Understandings and the Transfer Goals of each of the units taught throughout the semester (See Appendix B). The school mandated the Enduring Understandings and the Transfer Goals in Appendix B. Students were asked to try their best to answer each question and show their detailed work where possible.

After analyzing the result of each pre-assessment, students were placed in different sub-groups. Each sub-group was given concepts at an appropriate level. Students were encouraged to work collaboratively with their team members. In most cases, the teacher’s role was a facilitator and not the knowledge provider. The teacher rotated among the different groups and provided feedback and probing questions to guide students throughout the process of understanding the corresponding math concepts of
each unit. Some groups were taught via direct instruction methodology of teaching. The direct instruction groups lacked solid foundation in Algebra I, therefore, working with such a group was essential.

**Overview of the Case Study**

The purpose of this research is to investigate the relationship between students’ performance outcome and their experience in a differentiated classroom and to explore the researcher’s reflections on the experience.

When a teacher is differentiating instructional strategies, the teacher recognizes differences embedded in students; therefore, the academic differences will be addressed by modifying classroom instruction in order to support each learner in achieving his/her potential. This research will address the following questions:

1. How does students’ performance outcome relate to their experience in a differentiated instruction classroom?
2. What effects does the use of differentiated instruction have on the instructor?

**Case study design.** This research utilized a mixed methods design. The reason the researcher selected a combination of both qualitative and quantitative designs originated from the researcher’s belief in the depth and richness of knowledge acquired by capturing all details and trends of the situation. When used in combination, quantitative and qualitative methods complement each other and allow for more complete analysis (Greene, Caracelli, & Graham, 1989; Tashakkori & Teddlie, 1989). In order to form a cohesive conclusion, both quantitative and qualitative data will be collected simultaneously and analyzed separately.
To increase the consistency of the data collected, the research utilized detailed field-notes, documents of students’ journals (detailed in section 3.3.2-A), a sample of physical artifacts students provided (See Appendix C), lesson plans (See Appendix D), and all records used throughout the study.

To increase the validity of the data collected, a prolonged engagement in the field was established over a period of a whole semester, along with utilizing triangulation mixed method design as described by Creswell (2002). This design suggests a procedure of concurrently collecting both quantitative and qualitative data, followed by a detailed evaluation and report of the merging results. The interpretation of the data analysis was based on the importance and structure of information determined by the researcher (Creswell, 2002). To gain a broader knowledge and understanding of the research, the researcher used quantitative data as a support to qualitative data collected. As stated by Miles, Huberman, & Sanldana (1994),

The reasons cited most often for mixing both genres are (a) to provide analytic texture to your work, (b) to compensate for the deficiencies of one genre with the strengths of another, and (c) to modify or strengthen the analytic findings when the results of each genre support, corroborate, or contradict each other. (p. 43)

The procedure of collecting both types of data (explained in section 3.3.1, and 3.3.2) was used intermittently. The fieldwork involved a steady, integrated collection of both qualitative and quantitative data, as needed to understand the case at hand (Miles et al., 1994). The qualitative data was used to allow the researcher to better understand the reflection of participants in the study. As stated by Miles et al. (1994): “We have to face
the fact that numbers and words are both needed if we are to understand the world” (p. 42).

Since the weight of both types of data is equally important, the actual combination of both methods will occur in the data analysis chapter (Chapter Five).

**Researcher’s subjectivity.** As a secondary math classroom teacher, in a college preparatory school, the researcher has taught all students the same way for approximately a decade now. With the recent movement in education to improve students’ comprehension, and the appreciation of Differentiated Instruction, the researcher embraced the new methodology of teaching for approximately two years. This research study was conducted at the researcher’s place of work and the participants were her students.

Since 2016, the school has been embracing personalized education coupled with a big initiative towards differentiated instruction and the need to reach-out to all students. Prior to the school-wide decision on the new mission, the school hosted two differentiated instruction workshops for the community, elected two teachers to attend professional development opportunities across the states, encouraged all faculty members to attempt differentiation with the risk of failing, and urged an essential need for teachers to step back and allow the students to think, collaborate, and even fail sometimes. Tomlinson (2000) stated: “In today’s classroom, the key to effective teaching of mathematics is to help children learn to think, reason, and solve problems” (p. 151). In the early stages of implementing differentiated instruction in the classroom, it was a challenge for the researcher to step back and observe students struggling to reason and solve the problems assigned to them in their groups. Having
an open mind-set, changing the culture in the classroom to a student-centered environment, and stepping out of one’s comfort zone is never an easy task to do.

The extensive literature review discussed earlier proved the urgent need for effective instructional strategies of teaching and learning to maximize students’ growth and development. Therefore, this shift in the mathematics classroom was essential. Embracing differentiation did not mean assigning more practice problems for the advanced students and assigning less for struggling students; it meant understanding the learners’ level and working from that level to maximize growth and development. According to Tomlinson and McTighe (2006),

Teachers attempt to differentiate instruction by giving struggling learners less to do than other students and by giving more advanced students more to do than other learners. It is not helpful to struggling learners to do less of what they do not grasp. Nor is it helpful to advanced students to do more of what they already understood before they began the task. It is likely that the “more” or “less” approach to differentiation occurs when we lack clarity about essential outcomes and thus meaningful basis from which to differentiate. (p. 41)

In a differentiated classroom, teachers are always learning with students about how to help, motivate, and build on learners’ conceptual understanding of the material rather than focusing on procedural knowledge. Students might master mechanics of solving problems, however, if they cannot demonstrate their comprehension in different settings and cannot make conjectures in real life situations, then they might continue to struggle.
Since the fall of 2015, the school has been experimenting with differentiated instruction. Even though the majority of faculty members did not develop a high level of confidence to deal with differentiated instruction. Yet, the researcher considers herself very fortunate to embark on this mission and accelerate differentiated instruction in her mathematics department. The researcher unceasingly tried new processes and approaches to curriculum and instructional design and worked toward improving students’ comprehension and success.

The researcher was chosen by the head of school to attend the National Association of Independent Schools (NAIS) conference held at San Francisco, in spring of 2015-2016. The conference focus was differentiated instructional strategies. The numerous workshops the researcher attended during NAIS, were tailored to primary and elementary school levels. There was hardly any session for upper school (secondary) level. There are numerous high stake risks for changing instructional strategies of teaching and learning at secondary level classes due to The American College Test and Scholastic Aptitude Test standardized examinations for college acceptance. The shortage in professional development opportunities for Differentiated Instruction, in the upper school level, has intrigued the researcher to present her dissertation results at a professional conference when an opportunity permits.

**Case selection.** This research is conducted at a school that is located in an upper middle class community with about 60% of the student body coming from upper socioeconomic class families, and 20% of the student body are international students (English Language Learners, ELL). It is an elite co-educational, independent college-preparatory school in northwest Ohio.
The school is using a block-scheduling system. In an academic year, there are three intensives. Each intensive consists of three weeks, which are not related to the researcher’s field of study. The school year starts with an intensive and it ends with an intensive. The third intensive would fall at the end of the fall rotation, right before the start of the spring rotation. Each of the fall and spring rotation are 13-weeks long; during which, core content coursework is taught (See Appendix E).

It is the school mission to graduate globally aware students. Therefore, the combination of different cultures, coupled with dedicated faculty members and supportive administration is an exclusive environment for this research. Miles et al. (1994) described sampling in qualitative research involves two actions:

1. You need to set **boundaries**: to define aspects of your case(s) that you can study within the limits of your time and means that connect directly to your research questions, and that probably will include examples of what you want to study.

2. At the same time, you need to create a conceptual **frame** to help you uncover, confirm, or qualify the basic processes or constructs that undergird your study.

(p. 31)

Following Miles et al.’s (1994) key features of sampling, the researcher picked the two classes of Algebra II and used them as samples for this research. The samples were the only two Algebra II blocks, A and C, taught by the researcher. The sample classes and the participants inside each will remain constant throughout the semester while the research and data collection occurs.

**Participants.** As stated in chapter one, this research will use descriptive statistics to investigate how differentiated instruction affected students’ achievement in the course.
The research was conducted during the spring rotation in two sections of Algebra II classes running concurrently during the school year. Block A class consisted of sixteen, 10th grade Caucasian students, and block C class consisted of fourteen 10th graders. Block A had nine boys and seven girls. Block B had six boys one of whom was Chinese, and eight girls, one of whom was Chinese. The students involved in the research came from mixed socioeconomic statuses, races, cultures, and genders. Students ranged in a wide variety of abilities. Some students had Individual Education Plans for special needs and some were International students or English Language Learners.

Each Block met four days per week. The blocks’ times changed during the week depending on class rotation according to the master schedule. If the class happened to be before lunch then it was 85 minutes long, after lunch; it was a 70-minute class session. The schedule was the following:

Day 1: Blocks A, B, C, and D will meet (C and D are 70 minutes each).
Day 2: Blocks E, A, B, and C will meet (B and C are 70 minutes each).
Day 3: Blocks D, E, A, and B will meet (A and B are 70 minutes each).
Day 4: Blocks C, D, E, and A will meet (E and A are 70 minutes each).
Day 5: Blocks B, C, D, and E will meet (D and E are 70 minutes each).

The students in both sections of Algebra II classes used the same Prentice Hall Advanced Algebra Textbook. Each class was given a pre-assessment before the start of the research targeted units covered in the semester. Based on the performance of the students on pre-assessments, each class was divided into groups of compatible abilities. The researcher prepared activity sheets and lesson plans for different groups that were designed with their learning profiles, interests, and readiness levels in mind. The
instructional strategies among different groups differed depending on the readiness level of each. Some groups were taught via direct instruction methodology and some were working independently most of the time.

The researcher planned to tier the lessons, the activity sheets, the projects, and the methodology of teaching based on students’ readiness levels per group. Each sub-group was provided with supplemental problems, worksheets, and samples of application problems. Meaningful tasks, reinforcement activities, and extensions were used as needed based on student performance during the teaching period of each unit. This process was repeated for subsequent units for a period of a full semester.

All groups were provided a myriad of learning opportunities. Activities, materials provided to sub-groups, and projects were based on the readiness levels of students. Learning centers might demand group investigations, tiered activities, and compacting curriculum content and procedures.

Throughout the semester, a set time was given to students to reflect on their learning process, describing their experience in class, and explaining their reaction to this new methodology of teaching. This portion of the data collection was examined in detail as evidence for the qualitative portion of this case study. The researcher assigned the journal prompts and students had approximately 15 to 20 minutes to answer the prompts. The journals were placed in organized bins inside the classroom to provide easy access for students and the researcher to them.

While students were working on their journals, the researcher was working on her field-notes, documenting observations, reflecting on lessons, modifying processes for
The researcher used diagnostic, multiple summative, and formative assessments to evaluate students’ comprehension of the material. Some chapter quizzes were standards based questions generated by Prentice Hall Chapter Quiz generator software that comes with the Advanced Algebra textbook along with some teacher made quizzes. The researcher incorporated rubrics, quantitative scales for formative assessments, summative assessments, tiered lessons, activity sheets, sample problems, projects, artifacts, survey interviews, and students’ journals into this research.

**Types of data collected.** I collected the following six different types of data for this study:

1. Documentation in the form of students’ journals and the teacher’s lesson plans
2. Direct observation of classroom instruction
3. Participant observations in the form of researcher’s notes
4. Physical artifacts in the form of students’ projects and products
5. Survey interviews in the form of quantitative data
6. Formative assessments in the form of quantitative data

**Data Collection Procedures**

Review of research reinforced the fact that both qualitative and quantitative data were suitable for this case study. The qualitative and quantitative data will be collected concurrently. The goal is to use the depth and richness of information the qualitative research will provide to support the researcher’s quantified data collected. Reichardt and Cook (1979) stated three reasons to support the use of a dual approach to research:
1. Comprehensive research should include both process and outcome analysis.

2. Use both types allows each method to build upon the other.

3. Use of multiple techniques provides triangulation of the “underlying truth” separating the wheat from the chaff. (p. 21-23)

The focus of the researcher was convergent design of mixed methodological research. The broad overview of the quantitative data collected and its explanation in the qualitative data may provide an enhanced understanding of benefits of differentiated instructional design. Both quantitative and qualitative data were collected simultaneously and analyzed separately in order to form a cohesive conclusion.

With the permission of the Head of Upper School, the researcher was able to collect the data required during the spring rotation of 2015-2016. Since the researcher’s quantitative data was a normal procedure in the classroom, and the qualitative data was a normal process for each unit explained, collecting data was a standard process in the researcher’s classroom. As stated before, the participants were the researcher’s students in both sections of Algebra II classes.

In this research, the qualitative data collection procedure was represented via multiple sources. Robert Yin (2014) stated: “Case studies need not to be limited to a single source of evidence. In fact, most of the better case studies rely on a variety of sources (Loc. 3040). Documents as students’ daily journals, direct observations, participant observations, physical artifacts, survey interviews, and students’ formative assessments. All of the preceding will be detailed in the qualitative and quantitative design sections. Yin (2014) recommended six types of information to collect: documents, archival records, interviews, direct observations, participant observation, and
physical artifacts. In any case study, the data collection is typically extensive, and it draws on multiple sources of information to support the research. Furthermore, Yin (2014) discussed the importance of the mixed methods approach for case studies. In a mixed method approach, the quantitative data will complement the qualitative data and the researcher will have a richer and stronger array of evidence than can be accomplished by solely one approach.

Developing an in-depth understanding of the effects of differentiated instruction was based on both qualitative and quantitative data analyses. The descriptive nature of the qualitative research provided a framework for the processes occurring inside classrooms and how these processes were shaping students’ philosophies and opinions. Contrary to descriptive statistics of the quantitative research illustrated students’ achievement in class.

**Qualitative design.** The qualitative aspect of this research is exploratory in nature. It features the procedure of the new instructional strategy occurring in the classroom from students’, and the researcher’s perspective. The researcher explored the instructional strategies used in class would help mold students’ attitudes and beliefs toward the subject area being taught.

A thorough review of literature on best practices of differentiated instruction helped the researcher with the instructional strategies developed throughout the course. An initial discussion with the head of the upper school was performed to discuss the procedure of collecting both types of data and executing a plan of using differentiated instructional strategies inside the classroom. Being a faculty member in the school
alleviated the bureaucracy of going through scheduled interviews, background checks, and establishing of a set calendar among the researcher, participants, and administration.

In qualitative research, the researcher’s skills will largely effect the issue of validity and reliability. To ensure a good qualitative research, Miles et al. (1994) set some markers as instruments of a good qualitative researcher:

1. good familiarity with the phenomenon and the setting under study;
2. a multidisciplinary approach, as opposed to a narrow grounding or focus in a certain discipline;
3. good investigative skills, the ability to draw people out, and meticulous attention to detail;
4. being comfortable, resilient, and nonjudgmental with participants in the setting; and
5. a heightened sense of empathetic engagement, balanced with a heightened sense of objective awareness. (p. 42)

Although the researcher has been in the field of education for at least a decade, the research topic chosen, differentiated instruction in an upper school mathematics classroom, was a new expedition that needed to be further researched and developed. The lack of database in this field and the scarcity in literature prove any causation between differentiated instruction and students’ conceptual understanding remains a challenge.

Being familiar with the participants, expectations, and the actual environment where the research occurred has made the researcher more refined, focused, and swifter to shift from procedural practices to concentrating on the essential goals and significance
of this study. The strengths of the qualitative design of this research stems from its focus on ordinary events occurring in their natural setting. Miles et al. (1994) stated,

That confidence is buttressed by local groundedness, the fact that the data were collected in close proximity to a specific situation. The emphasis is on a specific case, a focused and bounded phenomenon embedded in its context. The influences of the local context are not stripped away but are taken into account. The possibility for understanding latent, underlying, or nonobvious issues is strong. (p. 11)

In this research, participants have been in the same classroom for a whole rotation, taught by the same instructor, the same subject area, with an emphasis on one new imposed phenomenon of teaching via differentiated instructional strategies.

An additional feature that gives the qualitative portion of this data its strengths is nested in the minute details that portray the holistic picture of the phenomenon studied. Qualitative data provides richness and holism, with strong potential for revealing complexity that can be described as “thick descriptions” (Greetz, 1973), which leaves a solid impression on the reader.

The first substantiated data source for this research was documents of students’ journals and lesson plans. As mentioned earlier students had multiple chances throughout the semester to reflect on their learning, experiences, and growth, as was appropriate based on the content. The researcher exposed learners to different types of prompts. Some prompts were open-ended questions, a sentence to complete, a quote to explain, a form of exit ticket, or multiple-choice question. The strengths of these documentations developed from being specific in the sense of references and details of the events,
unobtrusive in the sense of not being created as a result of the case study, and broad in
the sense that it covers a long span of time, different disciplines, and many settings (Yin,
2014). The evidence from these documents will provide an extra source for triangulating
data from projects, direct observations, and physical artifacts.

To construct validity of the documents in this case study, the researcher used
multiple sources of evidence. For example, all 30 students answered the same journal
prompts and were given the same amount of time to thoroughly complete them (Yin,
2014). To establish internal validity, the researcher did pattern matching by coding the
verbatim-transcribed data in ATLAS.ti (Yin, 2014). To guarantee the reliability of this
case, the researcher used case study protocol (Yin, 2014).

A second source of evidence for this case study was direct observations. Because
of the nature of this research, many opportunities presented themselves as a form of
direct observation. Some observations were formal and some were casual. A common
procedure for increasing the reliability of the observation is to have multiple observers. A
colleague and the head of Upper School did observe the researcher’s class and their
observation would be coded as part of this study.

Like any source of evidence, direct observation has its weaknesses and its
strengths. Yin (2014) explained the weaknesses of direct observations, as they tend to be
time consuming, reflexive, and sometimes selective. To avoid the reflexivity and the
selectivity aspect, the researcher was not informed of the time of the visit. The observers
strolled inside the classroom at different times and different days. Direct observations
have some highlighted strengths. Such as, their contextual nature and their immediacy in
covering actions in real time. Observers were looking at the context of differentiated instructional strategies in action and how teacher utilized these strategies.

A third form of collecting evidence for this case study was participant-observations. The researcher’s role as a participant observer in the field might have hindered the quantity of the field-notes. The researcher was participating in multiple roles simultaneously. Yin (2014) stated,

Participant-observation is a special mode of observation in which you are not merely a passive observer. Instead, you may assume a variety of roles within a fieldwork situation and may actually participate in the actions being studied. (Loc. 3055)

Having the researcher immersed in actual fieldwork prevented the opportunity for capturing all occurrences in the field. To avoid any biases of presenting evidences, participant observations were transcribed verbatim and coded into ATLAS.ti. The researcher did not interpret any observations the majority of the field notes taken by the participant were narrative description of the captured occurrences. The researcher focused on the interpersonal behavior among students in different groups.

The researcher used physical artifacts as the fourth source of evidence for this case study. All artifacts used were students’ produced work. Some were game boards, letters to classmates explaining the material, poems, posters, and other formats that relate to their interests and learning profiles (see Appendix C).

Though physical artifacts are viewed as less relevant in some case studies, sometimes they can be of great significance to the overall point the researcher is trying to claim. Yin (2014) stated, “Physical artifacts have less potential relevance in the most
typical kind of case study. However, when relevant, the artifacts can be an important component in the overall case” (p. 113).

For this study, the researcher chose artifacts created by students because they illustrate various intelligences (Gardner, 2004) in the classroom. Students who were artistically gifted chose the artistic method of expressing the knowledge acquired in class. Students with interpersonal intelligence expressed their comprehension of the material by designing a poster they presented to their classmates. Similar to other sources of evidence used in case studies, physical artifacts have their weaknesses and their strengths. They can be insightful into the environment and the context the researcher is trying to expose. At the same time, physical artifacts have weaknesses like selectivity and availability (Yin, 2014). To further counter selectivity, the researcher gave all students multiple options for presenting the knowledge they learned via a method of their choice. The same artistically gifted students presented their projects for every unit in some form of art, and the mathematically gifted students chose to do challenging mathematical problems. The researcher had multiple artifacts from each unit taught by the end of the semester.

Survey interviews were the fifth source of evidence for this case study. The researcher was conscious about the survey interviews, as there is a fine line between behavioral interviews and a structured survey interview (Yin, 2014). The details of the survey interview and the quantitative data produced as a result was considered only one component of the overall experience of the participants.

Further, survey interviews have strengths and weaknesses. According to Yin (2014), the strengths of survey interviews stems from being targeted and insightful. In
this case study, the researcher focused the questionnaires on differentiated instructional strategies and provided explanations as well as students’ views and perceptions about the topic. Some weaknesses remain in the reflexivity (Yin, 2014). Since reflexivity is considered a bias in survey interviews, the researcher offered questionnaires as journal prompts to students. Students engaged in answering the questionnaires by writing in their journals to minimize any physical reaction or response that might occur in face-to-face interviews.

The literature review suggested using different sources of evidence in case-studies, which allow the researcher to triangulate the data successfully. Yin (2014) stated:

The use of multiple sources of evidence in case study research allows a researcher to address a broader range of historical and behavioral issues. However, the most important advantage presented by using multiple sources of evidence is the development of conveying lines of inquiry. (Loc. 3164)

When sources of evidence triangulate and they aim to verify the same goal, the case study will be more convincing and accurate. Since the researcher is using a convergent parallel design, data triangulation among different sources helps strengthen the validity of this research.

In summary, this section has reviewed all six sources of evidence used in the qualitative portion of this case study. Collecting data remains a complex and challenging process because the researcher has to remain vigilant about the validity of the data collected and ensure a tight quality control of the variables that might present themselves within the procedure.
Qualitative data questions. This section will further discuss the details of the questions for each of the sources of evidence used in this case study. The goal is for the reader to establish foundations in understanding the multiple sources of evidence and how they relate to the research questions and the study.

Documentation. As discussed earlier, the researcher collected many documents relevant to the case study. The documents collected included students’ journals and lesson plans, throughout the semester. Students’ journals were transcribed into PDF files for easy storage and later transferred to ATLAS.ti for convenient retrieval of data. The varying importance of information and the amount of document collected throughout the semester necessitated the use of primary and secondary documents.

Participants: the 30 algebra II students in Blocks A and C

Tools: consisted of two parts: (A) students’ journal prompts and (B) multiple activity sheets as lesson plans for each lesson within each taught unit.

Part A: Students’ journals as documents were categorized in two parts:

Primary and secondary documents as deemed plausible by the researcher.

The primary documents in students’ journals were:

1. What is your favorite thing in this math class and why?
2. How are you motivated to learn in this classroom? What types of activities does your teacher do to help you learn in this class?
3. How do you think the instruction is geared towards your abilities?
4. How does your teacher give you feedback about your work in class?
5. How does your teacher offer you help when you need help with conceptual understanding?

6. How does learning math this semester differ in comparison to previous years? Explain.

7. If you can change one thing in this class what would that be?

8. If you can keep one thing constant among all classes you take, what would that be?

9. In the content of this course and setting, describe the:
   a. Who:
   b. What:
   c. Where:
   d. When:
   e. Why:
   f. How:

The secondary documents in students’ journals were the following:

1. Complete the following statements in terms of the content explained today:
   a. I feel confident about…..
   b. I am puzzled about……
   c. I can relate the material today to ……. 

2. Using your own words, can you explain what you have learned today?

3. Complete the following statement: The lesson today was ….
Data Location: All 13-journal entries noted above are written in students’ composition notebooks. The researcher transcribed the information verbatim in PDF files and consequently uploaded the data electronically to ATLAS.ti.

Part B: The teachers’ activity sheets used in the various lesson plans were electronically saved in PDF files. The researcher used color codes to differentiate among the tiered groups in each section.

Green Group: always represented the most competent group (Tier 3)
Pink Group: always represented the middle competency group (Tier 2)
Blue Group: always represented the least competent but not the most challenging group (Tier 1)
Orange Group: always represented the weakest group. This group had the most direct instructional strategies. The group lacked solid foundations in math especially in Algebra I. (Direct Instruction)

Data Location: Throughout the process of preparing the various tiered lesson plans according to students’ readiness, the researcher was using multiple resources. The researcher changed each lesson plan to four different levels of lesson plans and repeated the process for each lesson throughout the semester. As this process was time consuming and taxing on the researcher, it was very necessary to stay organized and to be efficient with time. All lesson plans were
stored electronically and saved as PDF(s) titled by section number and color (See Appendix D).

**Direct observations.** Two different observers made direct observation of the instructional strategy implemented in the lesson. The observers shared their reflections via a Microsoft Word document. The observers uploaded PDF files of the observations into ATLAS.ti for easy coding and data retrieval.

The classroom setting for the two algebra II classes was group based. The mobility of the tables and chairs inside the classroom made it convenient for the researcher to change the setting in the classroom according to the planned lesson of the day. Since the start of the second semester, the researcher changed the seating arrangement from two columns of four rows to four groups of three to four students in each group. This new seating arrangement increased collaboration among students since students faced each other in each group.

The students in each group had a colored box (related to the color group they are in) on their table with pencils, colored pencils, markers, rulers, and a set of flashcards of different activities that they could use for their projects (Explained in 3.3.2-D). Students’ composition notebooks, different rubrics, and extra material that students might need for their projects were all placed neatly on the researcher’s desk. During this period the researcher had no specific area designated to her. The researcher was always working with the students in different groups.

The researcher was able to collect two observation documents from two separate professionals in the field. The head of upper school walked in during one of the lessons without previous warning. He spent a block of 70 minutes in class observing the process
of going over assignments, explaining a new lesson, and wrapping up the time allotted in class. Throughout the process, his goal was to watch for differentiated instructional strategies and how the researcher was communicating with the students in the different groups. The Head of upper school sat with the different groups at different times. He made sure that the researcher and him were never with the same group at the same time. He interacted with the students and listened to their discussions. His observation was communicated to the researcher via a written document that the researcher saved as a PDF and transferred to ATLAS.ti.

The second observation happened by the Director of Students’ Support. Again, the director walked in the classroom without letting the teacher know of her time and date of observation. She rotated among the different groups, listened to students’ discussions, took notes, and participated in students’ discussions in their different groups. Her observation was communicated to the researcher via a written document that the researcher saved as a PDF and transferred to ATLAS.ti.

**Participant-observations.** Data recorded in the researchers’ journal entries and reflections using Microsoft Word documents uploaded as PDF(s) saved in ATLAS.ti for easy coding and data retrieval

Due to the fact that the researcher had multiple roles in the field, she was able to capture: students’ interactions with each other in different groups, students’ dominating conversations in different groups, students struggling with the material at hand, and fundamental issues the researcher needed to address in future lessons. It took a couple of lessons for students to appreciate the talents in their groups and to listen to every person
in their group. The researcher provided a check-list of expectations for each group and students were asked to follow the rules throughout the process.

The researcher worked on her journal entries and field observation notes while students were working on their journal prompts. It was a challenge for the researcher to scribe every note a student would say while working in groups; however, she tried her best to maintain well-documented journal entries.

**Physical artifacts.** These included Microsoft Word documents and 3-D products created by the 30 students in both sections of Algebra II. All physical artifacts were archived neatly in binders for easy retrieval.

The researcher provided the students in each group with a project they had three days to complete. Each group presented one project at the end of each section in each unit. The purpose of the projects was to allow students to express their creativity in multiple ways while demonstrating their understanding of the material.

It is important to note that the researcher tiered the projects based on students’ readiness and learning profiles. Meaning, a student in the green group will get the green project that is different than the project of a student in the orange group, for example. The researcher used the Tic-Tac-Toe boards as a format for projects. The Tic-Tac-Toe was adapted from *Differentiating Instruction* with Menus by Westphal (2013). Westphal (2013) described the Tic-Tac-Toe menu as:

Tic-Tac-Toe is a well-known, commonly used menu that contains a total of eight predetermined choices and, if appropriate, one free choice for students. These choices can range from task statements leading to product creation, to complex and/or higher level processing questions, to leveled problems for solving. (p. 8)
The researcher made sure to design different level problems for each Tic-Tac-Toe board. Each group of students were asked to work collaboratively and solve any three problems of their choice along with the Free Choice item in the middle of the board. The Free Choice item can be any activity they choose from a set of provided cards. Students needed to fill out a Free-Choice Proposal Form and submit it to the teacher for approval prior to their actual work (See Appendix F for sample of Tic-Tac-Toe projects).

Though problems on each board represented different levels of Bloom’s taxonomy, the researcher tried to include three different levels or objectives within a board. If the lesson had three different objectives, then the rows and columns of the board would have all three objectives covered in each. In a sense, Tic-Tac-Toe is viewed as a flexible activity as teachers can design problems to reinforce the material they taught in class in a different format. Westphal (2013) stated, “this menu can cover either one topic in depth or three different objectives within one content area” (p. 8).

One limitation for the Tic-Tac-Toe boards was the amount of material covered within. Westphal (2013) explained: “this menu only covers one or three topics” (p. 9). In addition to the limited strands of options a teacher can design on a Tic-Tac-Toe board, the students would have to finish either a row or a column to complete the Tic-Tac-Toe whether they are inclined to it or not. However, finishing the activity was compromised by the Free Choice space they could utilize (See Appendix G for a list of Free Choices permitted).

**Survey interviews.** I conducted survey interviews with the 30 students in both sections of Algebra II. I transcribed the responses to the questions in Microsoft Word documents and uploaded them to ATLAS.ti for easy retrieval.
I developed a few questions for all students to answer in their journals. The researcher opted to use students’ journals as tools to complete survey interviews to minimize reflexivity. Some questions were open ended and some were multiple-choice. The researcher sought detailed information with open-ended questions that would help with the structure of the classroom and the need for any modification if necessary. Open-ended questions were as follows:

1. How do you learn best and why?
2. What is your favorite subject at school and why?
3. What is your least favorite subject at school and why?

Other questions had multiple-choice options. They were as follows:

4. How often do you work in groups?
   1) All of the time  
   2) Some of the time  
   3) Almost never  
   4) Never

5. How often do members of the group change?
   1) All of the time  
   2) Some of the time  
   3) Almost never  
   4) Never

6. Learning math this semester has been:
   1) Too easy  
   2) Sometimes easy  
   3) just right  
   4) Too Difficult  
   5) Sometimes difficult

I used direct quotes and exemplary quotes from data collected when necessary. These quotes were analyzed to support the claim of the research and to assess whether data supports the conclusion. Fetterman (2010) stated: “Verbatim quotations are
extremely useful in presenting a credible report of the research” (p. 11). When the researcher provides exemplary quotations, the research will be more credible to show how the conclusion is supported by the data collected.

Once all the qualitative data was collected and multiple evidences are transcribed and stored electronically in appropriate programs like ATLAS.ti, I identified themes emerging in the data, assigning codes, and analyzing findings. Friese (2014) described ATLAS.ti as a system of linkages. As the researcher linked one item to the other, the process of understanding the data are clearer. At this stage of analyzing the qualitative data, looking for multiple forms of evidence to support each category will be important.

**Quantitative design.** Due to the fact that the researcher is the classroom teacher, quantitative data collection was a normal procedure in class. Some of the quantitative data would be categorical by nature, such as, questions four, five, and six in the survey interview. The researcher will display the results in a frequency table that represents the different answers from the 30 students included in this case study. The researcher will create a visual of the collected data. The visual will display findings in the form of a bar graph for questions four, five, and six. The researcher will be describing the frequency, the percentage frequency, and the relative frequency for each category given. A detailed description will be explained in Chapter Four.

Another set of important quantitative data would be students’ overall grade average in the semester. This includes projects, quizzes, tests, and cumulative exams. The researcher will be using descriptive statistics for this continuous set of data. The researcher will be analyzing the mean, mode, median, range, standard deviation, and variance of the data collected. Due to the fact that the sample size is 30 participants, the
researcher will be creating intervals to show the frequency, the proportions, the percentage, and the cumulative percentage of each interval. A thorough analysis of the descriptive statistics, defining scores and their location in the distribution by showing how many standard deviations away from the mean the individual score is in a normal distribution, will all be explained in chapter Four.

Quantitative data questions. As discussed earlier, I used two major sources of data in this case study: qualitative and quantitative statistics. Some of the qualitative data is categorical, the survey-interview, which leads to organizing the data in frequency tables with percentages and relative frequency, along with displaying results in bar graphs. The other portion of the quantitative data would be numerical and a result of teacher generated tests, quizzes, projects, and cumulative exams (Samples are in Appendix H). The researcher will be using frequency tables for the numerical data collected along with standard deviation and description of variance.

The procedure of analyzing the vast quantity of data collected involved using ATLAS.ti and the Microsoft Excel software.

The aim of the researcher is to determine whether findings of descriptive statistics merge and support the qualitative data analysis. Therefore, was there a correlation between students’ final semester grades and their experiences in the differentiated classroom? What worked well for all learners inside the classroom during the semester compared to previous years of teaching? How did differentiated instruction affect students’ confidence, if any? Similar to students’ experiences, how was the researcher’s experience? Was this method of instructional strategy very taxing on the teacher? Would qualitative and quantitative data merge to provide a comprehensive case
study? Once the qualitative and the quantitative data are analyzed, triangulation in the outcome should emerge. According to Denzin (1998), triangulation of data allows for the application and combination of several research methodologies in the study of the same phenomenon.
Chapter 4
Data Analysis

Along with analyzing the researcher’s experience throughout the process of this study, this research was conducted to show if there is any relationship between students’ achievement in a differentiated classroom and their overall experience in class as described in their journals. Qualitative and quantitative data were collected separately. Therefore, this data analysis chapter was divided into two major sections that would describe both types of collected data. Primarily, the researcher described the results of both data independently then the researcher studied the data conjointly to help answer the first and second questions of this exploratory study:

1. How does students’ performance outcome relate to their experience in the classroom?
2. What effects does the use of differentiated instruction have on the instructor?

Data Analysis Process

Throughout this study, there were multiple factors to be examined qualitatively and quantitatively. Qualitative data were composed of: documents, direct-observations, participant-observations, and physical artifacts. The process of analyzing qualitative data followed (Friese, 2014) analysis and it encompassed the following:

1. Transcribing data into word documents.
2. Saving data as PDF files.
3. Creating hermeneutic units (HUs) for each document.
4. Designing codes for data (in-vivo, descriptive, and process codes).
5. Organizing codes into families and merging codes to categorize data in smaller chunks.

6. Defining codes and relating them to differentiated instructional strategies.

The process of analyzing quantitative data encompassed the following:

1. The overall semester average for all 30 participants; including tests, quizzes, and final exam.

2. The quantified result of survey interviews. The quantitative data was saved in excel sheets.

**Qualitative Data Analysis**

The researcher discussed the qualitative data collected based on its category. The categories were: Documents, Direct-Observations, Participant-Observations, and Physical Artifacts. Each category is explained in details in this section.

**Documents.** As discussed in 3.3.2, data collected as documents consisted of students’ journal reflections and teachers’ lesson plans. This section of documentations was divided further into three sub-sections:

Primary documents, secondary documents, and teacher’s lesson plans.

**Primary documents.** Primary documents consisted of the most meaningful questions that relate to this study and corresponding answers participants provided. Primary documents were transcribed into word documents and were saved in PDF files and uploaded to ATLAS.ti as HUs. When the researcher started collecting data in forms of students’ journal, gaps of information were noticeable across the feedback. Gaps generated due to students’ misinterpretation of some questions, students’ absences, and lack of time to answer questions. To avoid any inconsistency in the process of collecting
journals feedback, the researcher had to scan the journal reflections periodically to check for completion. Miles et al. (2014) stated,

> We strongly advise analysis concurrent with data collection. It helps the fieldworker cycle back and forth between thinking about the existing data and generating strategies for collecting new, often better, data. It can be a healthy corrective for built-in blind spots. It makes analysis an ongoing, lively enterprise that contributes to the energizing process of fieldwork. (p. 70)

Though the researcher did not analyze the data while it was collected, she remained vigilant about having all participants complete their entries.

The researcher assigned multiple codes for the different data entries, merged the codes to minimize repetition, and created the following four families of codes to allocate the information based on the quantitative grade of the various participants.

*Code family A:* This code represented all participants who ended up with an A range grade for the semester. Code family A represented 70% of the total number of participants.

*Code Family B:* This code represented all participants who ended up with a B range grade for the semester. A13.33%, rounded down to 13%, of the total number of participants was represented in code B.

*Code Family C:* This code represented all participants who ended up with a C range grade for the semester. A 13.33%, rounded down to 13%, of the total number of participants was represented in code C.
**Code Family D:** This code represented all participants who ended up with a D range grade for the semester. A 3.33%, rounded down to 3%, of the total number of participants was represented in code D.

The code families (A, B, C, and D) were designed and connected to research question 1 (RQ1) as the researcher was trying to determine if there was an association between students’ quantitative performance outcome and their written qualitative journal reflections. Quotations were assigned to each code and the density and groundedness of each were written automatically beside each code (detailed in Appendix I). During the early stages of coding, the researcher assigned memos to some codes as an aid to help with data analysis. As defined by Friese (2014),

> To stay focused, adding a memo with your research questions can be done at an early stage of analysis. You probably already have a list of research questions, or at least some ideas. You can add further questions and ideas to this list with progressing analysis. (Loc. 2962)

Due to the amount of data collected, the researcher added RQ1 as a memo to the codes that were relevant to the collected data. Table 1 below, generated by ATLAS.ti, displays a distinct association between students’ positive feedback about differentiated instruction and the following: (1) the new imposed classroom structure, (2) the challenging material participants were exposed to, (3) the configuration of problem solving in groups, (4) the individual attention each group received, (5) the absence of lectures and peer pressure, (6) the increased motivation to learn, (7) the appreciation of the teacher’s role and participants’ roles, and (8) the significance of working at personal
pace in tiered groups. Similarly, the table shows one participant did not enjoy the new structure and was not in favor of the lack of lectures.

Table 1

*Qualitative research co-occurrence primary documents*

<table>
<thead>
<tr>
<th></th>
<th>Negative feelings</th>
<th>Positive feelings</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom structure</td>
<td>1</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>Enjoyable challenging material</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Group problem solving</td>
<td>0</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Individual attention</td>
<td>0</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Lectures</td>
<td>2</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Motivation</td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Peer pressure</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students’ task</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Teacher's role</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Teaching style</td>
<td>0</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Tiered groups</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Work at own pace</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

**Definitions of codes.** There were 12 codes that emerged in the documents included in this research and they are defined in the following list.

*Classroom structure:* This code is an in-vivo code. It is part of the Teacher’s Role in the classroom, which is associated with the Process and Interest aspects of differentiated instruction. It represented participants’ view of the classroom in terms of the homework routine, organization, classroom set-up, classroom environment, and consistency. This code aligned with RQ1.

*Enjoyable challenging material:* This code is an in-vivo code. It is part of Motivation in the classroom, which is associated with the Learning Profile and the Product of differentiated instruction. It represented participants’ view of the material that was given to them at different levels. This code aligned with RQ1.
Group problem solving: This code is a process code. It is associated with Student’s Task in the classroom, which is associated with how teachers can differentiate Content based on the Readiness level, and Interest of students. It represented participants’ description of how working in different groups was essential and how they could keep group work constant in other disciplines. This code aligned with RQ1.

Individual attention: This code is an in-vivo code. It is associated with Teacher’s Role in the classroom, which is linked to the Interest and Process aspects of differentiated instruction. It represented participants’ view on how the teacher was giving them feedback on their work and helped them conceptually understand the material. This code aligned with RQ1.

Lectures: This code is an in-vivo code. It is linked with the Teaching Style code, which is associated with the Interest and Process aspects of differentiated instruction. It represented participants’ view on how their math class this year differed from last year. This code aligned with RQ1.

Motivation: This code is an in-vivo code. It is associated with the Learning Profile and the Product of differentiated instruction. It represented participants’ view of the activities the teacher provided them to keep them motivated in class. This code aligned with RQ1.

Peer pressure: This code is an in-vivo code. It is associated with Individual Attention and Classroom Structure, which are linked to the Interest aspect of differentiated instruction. It represented participants’ view of how the classroom environment did not allow for peer pressure when asking questions and providing responses. This code aligned with RQ1.
**Student’s task:** This code is a descriptive code created by the researcher as she merged multiple codes describing students’ roles in the classroom. This code is linked to the Interest aspect of differentiated instruction. It represented participants’ view of what they thought their task was in their new classroom setting. This code aligned with RQ1.

**Teacher’s role:** This code is a descriptive code created by the researcher as she merged multiple codes describing the teacher’s role in the classroom. It is associated with the Interest and Process aspects of differentiated instruction. It represented participants’ view of the teacher’s role in class. This code aligned with RQ1.

**Teaching style:** This is an in-vivo code. It is associated with the Interest and Process aspects of differentiated instruction. It represented participants’ descriptions of the new teaching style. This code aligned with RQ1.

**Tiered groups:** This code is a descriptive code created by the researcher as she merged multiple codes describing participants’ feedback about the tiered groups in class. It is associated with the Readiness Level of differentiated instruction. This code aligned with RQ1.

**Work at own pace:** This is an in-vivo code. It is associated with the Readiness level and Content aspects of differentiated instruction. It represented participants’ descriptions of the work they were doing during class. This code aligned with RQ1.

**Families.** To align the qualitative data collected through students’ journals with RQ1, the researcher further analyzed the raw data ATLAS.ti generated to a higher level of analysis depending on each family (A, B, C, and D). Table 2 below displays the number of positive feedback quotations from each family along with the number of students in each.
Family A: Family A had 21 participants in all. Twenty participants described their experience in the differentiated instructional classroom as positive based on their written positive feedback quotations. 95% of participants’ feedback from family A was positive. Data showed that only one participant from Family A (1/21) did not appreciate the new experience with differentiated instruction.

Family B: Family B had 4 participants in all. All participants described their experience in the differentiated instructional classroom as positive, as written in their positive feedback quotations. 100% of the participants’ feedback from family B was positive.

Family C: Family C had 4 participants in all. All participants described their experience in the differentiated instructional classroom as positive, as written in their positive feedback quotations. 100% of the participants’ feedback from family C was positive.

Family D: Family D had 1 participant in all. The participant described his experience in the differentiated instructional classroom as positive, as written in his positive feedback quotations. The feedback from 100% of the participants in family D was positive.
Table 2

Qualitative Research Co-occurrence Primary Documents Table per Family-per Student

<table>
<thead>
<tr>
<th></th>
<th>Family A</th>
<th>Family B</th>
<th>Family C</th>
<th>Family D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative quotations</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Positive quotations</td>
<td>115</td>
<td>18</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td># of students reporting negative feedback</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># of students reporting positive feedback</td>
<td>20</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>% of students reporting positive feedback</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>% of quotations reporting positive feedback</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 2c below represented a visual chart for the data in a bar graph form. The bar graph showed that families B, C, and D consisted of 100% positive feedback reported by participants via their positive written quotations. Similarly, 95% from Family A reported positive feedback via their positive written quotations.

![Bar graph showing percentage of students and quotations reporting positive feedback](image)

**Figure 2. Qualitative Feedback as Reported by Families**

*Secondary documents.* As mentioned earlier, secondary documents were part of students’ journals. They mainly focused on students’ feedback on a certain topic discussed during class. The goal was to determine if students understood the material
explained in class. Secondary documents served as exit tickets at the end of class. Though the researcher transcribed all secondary documents and saved them as HUs in ATLAS.ti, the researcher did not find it important to analyze the secondary documents data in this case study because they did not relate to either research question.

**Teacher’s lesson plans.** The classroom teacher has been in the field of teaching mathematics for high school students for approximately 13 years now. The teacher spent at least a decade teaching students in a traditional way. The teacher would stand in front of the class to lecture students and reveal the secrets of solving certain types of problems. The teacher would explain and solve problems on the board. The students were to copy the notes, be attentive during explanation, and practice some more problems at home. The monotonous routine would repeat every day for a period of 50 minutes. Some students excelled in this environment while the majority of students were left to struggle and try harder.

Attending professional development conferences about adolescent brain development and ways to help students retain information in class coupled with reading literature about new trends in education intrigued the teacher to change her approach to teaching and learning. Differentiated instruction was the new avenue to pursue. As Tomlinson (2000) explained, a teacher could differentiate based on content, process, and product while attending to students’ readiness levels, interests, and learning profiles.

Upon making the decision to utilize differentiated instructional strategies, the teacher needed to clear this decision with the administration and request new furniture in her class which would promote collaboration and brainstorming within tiered groups. When the teacher’s request was granted by the administration, the teacher started
collecting multiple mathematics textbooks, used on-line resources, and utilized multiple books to provide different activities for students at different levels. The teacher followed Tomlinson’s (2013) model for creating differentiated units. The routine before starting any unit was the following:

1. Pre-assess students’ knowledge of the unit (Chapter) by giving all students the same pre-assessment.
2. Based on the result of the pre-assessment, students were placed in groups of compatible levels. Each group was denoted by a color: Green, Pink, Blue, and Orange.
3. Based on the tier of the group, design lesson plans for each section in each unit.
4. Design tiered group projects and activity sheets to adapt to each tier (see Appendix D).
5. Prepare supplies, rubrics, and multiple resources for all students to use.

For each lesson planned, the teacher spent ample time finding activities, problems, and projects to keep students motivated and engaged in the lesson. Therefore, the teacher was differentiating across all three aspects of differentiated instructional strategies: content, process, and product. The teacher’s role was the facilitator and not the knowledge provider. Students were expected to work collaboratively in their groups to figure out the problems that were assigned to them. The teacher rotated among the different groups and answered students’ questions indirectly by asking them about their thought processes and their reasons for solving problems in a certain way.

The teacher gave individual attention to all her students by working with them individually at their tables. In the early stages of this teaching style, the introverts were
challenging to work with; however, once they established the trust among their team members, the dynamic of the whole class changed. The traditional classroom turned to a group of people working together with one common goal that would maximize the growth and development of each student in class. The environment in class was stress-free, trusting, and comfortable for all to work in. Students were always captivated by the work at hand, and most of the time, the teacher struggled to send them off to their next block.

**Direct observations.** As discussed earlier in, two different professionals in the field shared their direct observations of the instructional strategy implemented in the lesson as reflections in PDF files. The Head of Upper School and the Director of Students’ Support shared their observations with the researcher as two separate PDF files. The researcher uploaded the PDFs to ATLAS.ti and saved them as HUs. After the process of coding the data, looking for patterns in the data, and analyzing the findings, an obvious pattern between the two documents emerged. The two observers confirmed the presence of differentiated instructional strategies in the researcher’s classroom.

Table 3 below, generated by ATLAS.ti, displays rich similarities in the way Observer One described the instructional strategies used in the classroom in comparison with Observer Two. Both observers reported similar classroom structure, similar description of teacher’s attitude toward students, teacher’s expectations of students, teacher’s role in the classroom, and teacher’s passion toward the subject and the students.

One observer clarified the need for some strategies to be implemented to encourage the few introvert students to feel comfortable with the rest of their group members. Similarly, observer two pointed out the nourishing environment more than
observer one did. The majority of the other elements of implementing differentiated instructional strategies in the classroom were similar.

Table 3

Qualitative Research Co-occurrence Primary Documents Table for Direct Observations

Generated by ATLAS.ti

<table>
<thead>
<tr>
<th></th>
<th>Direct Observation (P1)</th>
<th>Direct Observation (P2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Students' attitude</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>A. Teacher's attitude</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Classroom structure</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Collaboration</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Develop differentiated unit</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lack of collaboration</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Nurturing environment</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Teacher’s passion towards students</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Teacher’s passion towards subject</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Student's task</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Students' engagement in class</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Teacher's expectations</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Teacher's role</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Tiered groups</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Definitions of codes. There were 14 codes that emerged in the observation portion of this research. They are defined in the following list.

Teacher’s attitude: This code is an in-vivo code. A Teacher’s Attitude is a sub-code of Attitude. It explained how the observers viewed the teacher’s interactions with the students and how the teacher came across during the lesson. This code is associated with participant-observations to determine if there is commonality in the description of the overall teacher’s attitude in class. It is linked to RQ2.

Student’s attitude: This code is an in-vivo code. Student’s Attitude is a sub-code of Attitude. It explained how the observers viewed the participants’ interactions with
each other and with the teacher during class. This code is associated with participant-observations to determine if there is commonality in the description of students’ attitude in class. It is linked to RQ2.

*Classroom structure:* This code is an in-vivo code. It is linked to Teacher’s Role. It explained how the observers viewed the organization, the set up, and the flow of the class in all. This code is associated with the participant-observations to determine if there is commonality in the overall description of class. It is linked to RQ2.

*Collaboration:* This code is an in-vivo code. It is linked to Tiered Groups. It explained how the observers viewed the different groups dynamics. This code is associated with participant-observations to check if there is commonality in the overall description of class. It is linked to RQ2.

*Develop differentiated units:* This code is a descriptive code. It is linked to Teacher’s Role. It explained viewers’ goal of the observation and how the teacher and students engaged in a differentiated instructional strategy classroom. This code is associated with the participant-observations to study the commonality in the overall goal of class. It is linked to RQ2.

*Lack of collaboration:* This code is an in-vivo code. It is linked to Tiered Groups. It described the observers’ view of the introverts in class. Some strategies were provided to overcome this issue. This code is associated with participant-observations to study the commonality in the overall goal of class. It is linked to RQ2.

*Nurturing environment:* This code is an in-vivo code. It is linked to Teacher’s Role. It explained the observers’ view of the classroom atmosphere. This code is
associated with participant-observations to study the commonality in the overall goal of class. It is linked to RQ2.

Teacher’s passion towards students: This code is an in-vivo code. It is linked to Teacher’s Role. It explained the observers’ view of the teacher as she was working with different groups at different tables. This code is associated with participant-observations to determine if there is commonality between what was observed and teacher’s actions. It is linked to RQ2.

Teacher’s passion towards the subject: This code is an in-vivo code. It is linked to Teacher’s Role. It explained the observers’ view of the teacher as she was teaching students. This code is associated with participant-observations to determine the commonality between what was observed and teacher’s actions. It is linked to RQ2.

Student’s task: This code is a descriptive code. It is linked to Tiered Groups. It explained the observers’ view of students’ roles as they were working with each other and as they were following the rules the teacher set for the class. This code is associated with participant-observations to determine if there is commonality between what was observed and teacher’s actions. It is linked to RQ2.

Student’s engagement in class: This code is an in-vivo code. It is linked to Tiered Groups. It described the observers’ view of students and their level of engagement. This code is associated with participant-observations to determine the commonality in the overall goal of class. It is linked to RQ2.

Teacher’s expectations: This code is an in-vivo code. It is linked to Teacher’s Role. It described teacher’s expectations as deemed by the two observers. This code is
associated with participant-observations to determine the commonality in the overall goal of class. It is linked to RQ2.

**Teacher’s role:** This code is an in-vivo code. It described teacher’s role in a differentiated classroom as described by the two observers. This code is associated with participant-observations to determine the commonality in class overall. It is linked to RQ2.

**Tiered groups:** This code is an in-vivo code. It defined the observers’ descriptions of the different groups the teacher had in class. This code is associated with participant-observations to determine the commonality of the description overall. It is linked to RQ2.

Figure 3 represents a visual chart of the data in a bar graph form. The bar graph showed that both observers gave a similar analysis to the dynamic of the class. This figure gives the reader a visual of how close of an analysis the two observers gave with their direct observation feedback. They both discussed the same marking points of any differentiated instruction classroom. They repeatedly discussed students’ and teacher’s attitude in class and how enjoyable the experience has been to all constituents in class. The observers conferred the dynamic in classroom structure, students’ tasks and teacher’s role in a differentiated classroom. They both discussed the high level of engagement, collaboration in the tiered groups, and the nurturing classroom environment.
Figure 3. Qualitative feedback as reported by the direct observers

**Participant-observations.** Part of this study was the teacher keeping her own journal entries and writing memos of students’ verbal expressions and reactions to the shift in teaching and learning. Some journal entries were well written paragraphs, some were bullet points, and others were jottings of notes as short memorandums written by the teacher. As discussed earlier in 4.1, the data was collected as journals, transcribed into PDFs, uploaded to ATLAS.ti as HUs, and coded for analysis and reference.

Table 4 below, generated by ATLAS.ti, displays a distinct association between participant-observations and direct observations. The same common themes that occurred in direct observations also occurred in participant-observations. The codes’ definitions for these themes are the same as 4.2.2-A.
Table 4

*Qualitative Research Co-occurrence Primary Documents Table for participant-observations*

<table>
<thead>
<tr>
<th></th>
<th>Participant-Observations</th>
</tr>
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<tbody>
<tr>
<td>Classroom Structure</td>
<td>13</td>
</tr>
<tr>
<td>Collaboration</td>
<td>16</td>
</tr>
<tr>
<td>Development of Differentiated Unit</td>
<td>21</td>
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<td>Lack of Collaboration</td>
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<td>Nurturing Environment</td>
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<tr>
<td>Students' Attitude</td>
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<tr>
<td>Students' Engagement in Class</td>
<td>13</td>
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<tr>
<td>Students' Task</td>
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<tr>
<td>Teacher's Attitude</td>
<td>32</td>
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<tr>
<td>Teacher's Expectations</td>
<td>15</td>
</tr>
<tr>
<td>Teacher's Role</td>
<td>33</td>
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</tbody>
</table>

Figure 4 below represents a visual chart for the data in a bar graph form. The bar graph shows that participant-observations occurred with similar analyses given by the two observers in 4.2.2. This figure gives the multiple occurrences of codes. It is important to note the frequency of codes in participant-observations exceeded the frequency of those in direct observations, simply because direct observations materialized two separate times, while participant-observations took place fifteen separate times. Data from both resources, direct observations and participant-observations, examined the same marking points of any differentiated instruction classroom. For example, tiered groups, nurturing environment, classroom structure, students’ and teacher’s attitude in class, and collaboration among students and with the teacher were all factors creating a good experience for all constituents in class.
Physical artifacts. Physical artifacts were part of this study. The researcher followed the same methodology for presenting the artifacts discussed in this study:

1. Location of the Document
2. Document Number
3. Physical Description of the Document
4. Description of the Context
5. Analytic Notes

The researcher discussed a sample of three different artifacts for this study.

Physical artifacts - Sample A. This document is located in Appendix C and is document number 2016. 2 Doc # 1: ACROSTIC. It was collected by Laila Ariss, Wednesday, February 3, 2016.
This was the first time the researcher collected projects from students. A student from the pink group designed this particular Parabola Properties ACROSTIC. As the students were provided by variety of free choices, this student opted on doing the ACROSTIC. The student thought this would be the best way for him to remember the properties of parabolas. The guidelines for the ACROSTIC were the following:

- Must be at least 8.5” by 11”.
- Must be neatly written or typed.
- Target word should be written down the left side of the paper.
- Each descriptive phrase chosen must begin with one of the letters from the target word.
- Each descriptive phrase chosen must be related to the target word.

*Physical description of the document.* 2016. 2 Doc # 1: is a copy of the student ACROSTIC designed work. In addition to the original copy being saved in a folder with other artifacts, the researcher kept an electronic copy as a scan saved as a picture in the research folder.

*Description of the context.* Parabolas’ property was the topic the researcher started with during the first few days of the second semester. The researcher used this document to expose the reader to different ways students like to express the learning and comprehension of the material studied. The student definitely understood the learning objective for that particular lesson and had the choice to express his comprehension of the material, as he considered appropriate. As was mentioned in the literature review, a teacher who is differentiating based on process according to students’ learning profiles, will allow students to have varied ways of completing homework. As educators, we
should be aware of learning differences among our students; therefore, it is important to
differentiate our instructional strategies and be flexible with students.

*Analytic notes.* Looking at the student’s work and the learning objectives of the
lesson, the student definitely accomplished all benchmarks. This lesson was connected to
a larger unit about quadratic functions and understanding the basic properties of quadratic
equations is vital to forming a foundation for the whole unit ahead. The student’s
document is associated with course overviews as explained in Appendix B.

Throughout the years, the researcher has been challenged to cover the bulk of the
content material and help students retain the knowledge within a single school year but
was never able to accomplish this goal to full capacity. Therefore, the researcher was
concerned about allowing students some choices in expressing their learning based on
their learning profiles. However, the result was gratifying because students showed signs
of growth and development within the context of this class.

*Physical artifacts – Sample B.* This document is located in Appendix C.

Document number 2016. 2 Doc # 2: Three Facts and A Fib. It was collected by Laila
Ariss, Thursday, February 11, 2016.

A student from the blue group designed this particular poster for three facts and a
fib. As the students were provided multiple options for a free choice to express the
learning objectives of the lesson, this student opted to complete Three Facts and a Fib.
The student thought this would be an easy way for her to remember the different formats
of quadratic equations. The guidelines for the Three Facts and a Fib were the following:

- Must be written, typed, or created using PowerPoint.
- Must include exactly four statements: three true statements (facts) and one false statement (fib).
- False statement should not be obvious.
- Must include a brief paragraph that explains why the fib is false.

*Physical description of the document.* 2016. 2 Doc # 2: is a copy of the student-designed work of Three Facts and a Fib. In addition to the original copy being saved in a folder with other artifacts, the researcher kept an electronic copy as a scan saved as a picture in the research folder.

*Description of the context.* The comparison between Standard and vertex forms of a parabola was the topic explained by the researcher. Students needed to understand what each term stood for and how to convert from one form to the other. The researcher used this document to expose the reader to different ways students demonstrated their learning and comprehension of the studied material. The student definitely understood the learning objective of this particular lesson and had the choice to express her comprehension of the material, as she considered appropriate.

*Analytic notes.* Looking at student’s work and the learning objectives of the lesson, the student definitely accomplished all benchmarks. This lesson is connected to a larger unit about quadratic functions. The work is associated with the course overviews as explained in Appendix B. The researcher was definitely fascinated by the different products the students designed throughout the first few weeks. The researcher is displaying students’ work in the classroom and planning to keep most of it as exemplars for many years to follow.
Physical artifacts – Sample C. This document is located in Appendix C. It is document number 2016. 2 Doc # 3: Instruction Cards and was collected by Laila Ariss, Tuesday, March 8, 2016.

A student from the green group designed these particular instruction cards for polynomials and linear factors. As the students were provided multiple options for a free choice to express the learning objectives of the lesson, this student opted to complete the instruction cards. The student thought this would be a way to integrate the graphs of polynomials with their linear factors. The combination of the graph of the polynomial, the solution, and the explanation would make it easy for the reader to understand the concepts behind the lesson. The guidelines for the Instruction Cards were the following:

- Must be no larger than 5’’ by 8’’.
- Must be created on a heavy paper or index card.
- Must be neatly written or typed.
- Provides instructions stated in the task.

Physical description of the document. 2016. 2 Doc # 3: is a copy of the student-designed work of Instruction Cards. In addition to the original copy being saved in a folder with other artifacts, the researcher kept an electronic copy as a scan saved as a picture in the research folder.

Description of the context. The connection between the graph of any polynomial and its zeros is a concept that is necessary for students to understand. The researcher used this document to expose the reader to different ways students like to express their learning and comprehension of the studied material. The student demonstrated
understanding of the learning objectives for this particular lesson and had the choice to express her comprehension of the material, as she considered applicable.

Analytic notes. Looking at student’s work and the learning objectives of the lesson, the student demonstrated her understanding of the material. This lesson is connected to a larger unit about polynomials and Their Graphs. The work is associated with the course overviews as explained in Appendix B. The researcher was definitely impressed by the different products the students designed throughout the units. The researcher continued displaying students’ work in the classroom.

Summary of the qualitative data findings. Overall, the analysis of students’ journal reflections about their experience in a differentiated classroom was positive. The collected data revealed that majority of the students enjoyed the following: the new classroom structure where the teacher was not standing at the board talking at all of them, the challenge the new material imposed on students which did not permit for boredom, the collaboration among members in smaller groups, the attention students received when the teacher worked with them in smaller groups, the process of obtaining knowledge when they were asked to think, the dynamic of the class which kept them motivated to learn, the nurturing environment where peer pressure was diminished, the teaching style when the teacher was a facilitator not a knowledge provider, the tiered groups configuration based on competency levels, and the pace of the class as all students were challenged at different levels.

The direct-observations in this case study served as a confirmation tool for the various occurrences and procedures in the participant-observations. Due to the fact that differentiated instruction is relatively new in the world of education, developing
differentiated units was not an easy task to accomplish. The teacher had to be organized, efficient with time, resourceful with activities, and instantaneous in providing individual students with feedback.

By looking carefully at the lesson plans the teacher designed, the physical artifacts the students provided, and the participant-observations data, this study enhanced the researcher’s understanding of why using differentiated instruction is a must in every classroom, especially in mathematics where educators teach students as if they were all intellectually identical.

Furthermore, the findings of this data were important for the teacher as they contributed to understanding the struggles of students and providing tools to increase their achievement. The teacher realized the hidden talents and abandoned creativities that dwell within each student in the classroom. Therefore, differentiating the process, product, and content of acquiring knowledge according to students’ readiness, interest, and learning profile through the range of different activities, and small group instruction were appropriate as they left a positive impact on the students and the teacher.

**Quantitative Data Analysis**

In this case study, the researcher had two different sets of quantitative data: The survey-interview questions participants answered in their journal reflections and the overall semester average. These two sets of data are analyzed below.

**Survey-interviews.** Part of the students’ journal reflections was to answer multiple questions throughout the semester. Though some questions were qualitative in nature, they were categorical. The scale of measurement was a nominal scale, as the number attached to the options of multiple-choice questions did not have a numerical
value per-say; these numbers represented related categories of answers. The questions were:

1. How often do you work in groups?
   1) All of the time
   2) Some of the time
   3) Almost never
   4) Never

5. How often do members of the group change?
   1) All of the time
   2) Some of the time
   3) Almost never
   4) Never

6. How was learning math this semester?
   1) Too easy
   2) Sometimes easy
   3) Just right
   4) Too difficult
   5) Sometimes difficult

*Question one (Q1).* How often do you work in groups? The researcher transcribed the data collected for this question and saved it as an excel file. The researcher uploaded the excel file to ATLASI-ti as a HU. After analyzing the responses from participants for this specific question, the researcher noticed that all 30 participants provided the same answer for this question. Therefore, 100% of the participants confirmed they continuously worked in groups. This result established confirmation between participant’s observations and direct-observations analyzed earlier in chapter four. All 30 participants stated they were working in groups all the time. Table 5 below displays the result of the survey data for question one.
Table 5

*Qualitative Research Co-occurrence Primary Documents Table for Survey-Interviews Q1*

<table>
<thead>
<tr>
<th>Participants</th>
<th>All of the time</th>
<th>Some of the time</th>
<th>Almost never</th>
<th>Never</th>
</tr>
</thead>
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</table>

Figure 5 below represents a visual chart for the data in a bar graph form. The bar graph shows that survey-interview results for question one were consistent among all 30 participants.
Figure 5. Qualitative feedback as reported by participants for Q1

*Question two (Q2).* How often do members of the group change? Furthermore, the researcher transcribed the data for question two above and saved it as an excel file, the researcher uploaded the excel file to ATLASI-ti as an HU. After analyzing the responses of students for question two, the researcher noticed approximately 77% of the participants said their group members changed most of the time, while about 17% of the participants stated their group members almost never changed, and about 6% of the participants said their groups changed all the time. Table 6 below displays the results of question two.
Table 6

*Qualitative Research Co-occurrence Primary Documents Table for Survey-Interviews Q2*

<table>
<thead>
<tr>
<th>Name</th>
<th>All of the time</th>
<th>Some of the time</th>
<th>Almost never</th>
<th>Never</th>
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Figure 6 below represents a visual chart for the data in a bar graph form. The bar graph showed that survey-interview results for question two were falling at different intervals. However, the majority of participants confirmed their groups were changing some of the time. It is important to note that the 17% of participants who stated their groups almost never changed, could relate to the fact that these participants fell either on the lowest tier level or the highest tier level as these two tiers were constant the majority of time.

![Figure 6](image-url)

*Figure 6. Qualitative feedback as reported by the participants Q2*

*Question three (Q3).* How was learning math this semester? Similarly, the researcher transcribed the data for question three above and saved it as an excel file. The researcher uploaded the excel file to ATLASI- ti as a HU. After analyzing the responses of students for question three, data showed approximately 67% of the participants said the material given to them was just right, while about 20% of the participants stated that
the material was too difficult for them, 10% of the participants said the material was too easy for them, and about 3% of the students said the material was sometimes difficult.

Table 7 below displays the results of question three.

Table 7

*Qualitative Research Co-occurrence Primary Documents Table for Survey-Interviews Q3*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Too easy</th>
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Figure 7 below represents a visual chart for the data in a bar graph form. The bar graph showed that survey-interview results for question three were falling at different intervals. However, the majority of the participants stated the material that was given to them was just right. Thus, the majority of participants were given material that was just right for their competency level. It is important to note that no student found the material too easy for them. Similarly, only the family D participant found the material to be sometimes difficult.

![Bar Graph](image)

Figure 7. Qualitative feedback as reported by the participants for Q3

Overall semester averages. As mentioned earlier, part of the quantitative data were participants’ averages over the semester. The overall average included all quizzes, tests, and projects participants submitted to the researcher for a grade. After entering the data into an excel sheet and looking at the pattern generated, the researcher divided the data into four different families. Families: A, B, C, and D. It is important to mention that
an A range is 90% - 100%, B range is 80% - 89%, C range is 70% - 79%, and D range is 60% - 69%.

Table 8 below displays the data as numerical and letter values. Looking at the data generated below, there were 21 students in the A family, four students in the B family, four students in the C family, and only one student in the D family. There was no extra credit awarded to the students, no assessment retakes, and no scaling or adjustments to the students’ grades. Among the 30 participants, the maximum average was 99% and the minimum average was 69%. Thus, the range of the data was 30. The median of the data was 93%, the mode of the data was 97%, and the sample mean (x bar) was 90.46%.
Table 8

Quantitative Research Co-occurrence Table for Students’ Averages Generated by Excel

<table>
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<th>Letter Grade</th>
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<td>P30</td>
<td>69</td>
<td>D</td>
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Figure 8 below represents a visual chart for the data in a bar graph form. The bar graph showed that 70% of the participants scored in the A range, 13.33%, rounded down to 13%, of the participants scored in the B range, 13.33%, rounded down to 13%, of the
participants scored in the C range, and 3.33%, rounded to roughly 3%, scored in the D range.

![Final Average](image)

**Figure 8.** Quantitative research as generated by excel program

Looking at the frequency table, the majority of the data fell to the right of the horizontal axis, away from the origin, with a tail extending to the left of the frequency values (mean, mode, and \( x \) bar); therefore, the data is skewed to the left. Thus, most of the data fell to the right of the mean (\( x \) bar), including the median and the mode.
Figure 9. Frequency table for students’ averages generated by excel. The table shows how the data is skewed to the left simply because the median (M) is greater than the sample mean (x bar) of the data, in the same time, the median (M) is less than the mode (m), therefore, x bar < M < m (M = 93, m = 97, x bar = 90.46).

Since the data is skewed the researcher calculated the quartiles Q2, Q3, and Q1. Q2 was 93, which is equal to the median of the data. Thus, 93 is the mid number of the data when all datum points are organized in ascending order.

Q2 that is equal to 93 divided the data above into two equal parts: the data to the left of Q2 and the data to the right of Q2. Therefore, Q1 occurred as a median to the data on the left of Q2, and Q3 occurred as a median to the data on the right of Q2. Q1 had a value of 83.5 and Q3 had a value of 97. The data now is divided into four quartiles:

Quartile 1: 69  76  76  78  79  81  83  ||  84  88  91  91
            92  92  93  93  94  94  94  95  96  96  97  ||
            97  97  97  97  98  98  99

Quartile 2: 84  88  91  91  92  92  93
Quartile 3: 94  94  94  95  96  96  97
Quartile 4: 97  97  97  97  98  98  99
The inter quartile range (IQR) = Q3 – Q1 = 97 – 83.5 = 13.5 since the IQR was relatively small, the data were less dispersed in the middle 50% of the distribution which is clearly the case in the frequency chart. When the researcher discussed the frequency table in chapter five, she focused on the seven participants in quartile one. The general reader might think the participants in quartile one provided a negative feedback about the class due to the grades they ended up earning. Therefore, the researcher analyzed the qualitative data of the seven students with a precise lens to determine if quartile one participants’ performance outcome relate to their experience in a differentiated classroom. The quantitative data positively supported the qualitative data in this research. Most of the students performed above average and they were receptively in favor of differentiation.

**Preview of Chapter Five**

Chapter five discusses the findings of this research and how the qualitative data merged with the quantitative data to answer RQ1 and RQ2. The researcher explores the codes of the qualitative data, relates them to the quantitative data, and further discusses the methodological triangulation of both types of data. The convergent parallel design of this case study will present the answers to the research questions, the implications of the study on teachers and pre-service teachers, the limitations of this research, and possible related future research.
Chapter 5

Results and Discussion

This chapter reviewed the findings of this case study by answering research question one and two (RQ1 & RQ2). The chapter started with results of each qualitative data code, related it to quantitative data analysis, and examined the methodological triangulation of both qualitative and quantitative data. A summary of the results was illustrated in a discussion paragraph at the end of each section. The researcher divided the discussion into discussion of RQ1 and discussion of RQ2, when it was suitable. The researcher brought differentiated instruction and literature review in the discussion of data results. At the end of this chapter, the researcher included implications of this study on the literature, limitations, and recommendations for further research.

Results

This section started with a discussion of the various codes of the qualitative data collected across the different categories in chapter IV. Qualitative data were supported by actual quotes from the participants, direct-observers, and participant-observer to validate the authenticity of the findings and provide the reader a sense of what to anticipate in each section. The quantitative data discussion followed the qualitative discussion of each code.

In order to have coherent results and discussion, it is important for the researcher to gather both types of data, qualitative and quantitative, and to explain the integration of results. Therefore, the researcher discussed the methodological triangulation of the data results and supported it by a discussion of the literature review and the framework for
differentiated instruction as identified by the participants, direct-observations, participant-observations, physical artifacts, survey-interviews, semester averages, and lesson plans.

According to the data analysis presented in chapter IV, the majority of participants provided positive feedback to the many aspects of a differentiated instruction classroom. The participants appreciated the following: classroom structure, challenging material, group problem solving, individual attention, lectures, motivation, lack of peer pressure, student’s task, teacher’s role, teaching style, tiered groups, and work at own pace. Each sub-category is discussed in details.

**Classroom structure.**

*Qualitative evidence.* RQ1: Classroom structure included the organization of the material, working collaboratively with team members, having students think on their own, rotating among groups, varying activities students were engaged in, establishing an individualized learning experience, and reviewing assignments were all part of the classroom structure. The majority of participants, 29 out of 30 participants, appreciated the fact that the teacher was not standing in front of them and teaching them the same material all at once. Participant # 8 stated: “I like how interactive we are in class with our group members and how we have activities to do.” with the exception of one participant who did not like the structure as she felt other students were working on different problems. Thus, she was not sure if she was being exposed to all the material needed for class, or if she was only receiving a portion of it. Participant # 24 stated: “Last year, math class included a lot of notes and the teacher standing in front of the board. I found that I definitely enjoy being able to take notes and see examples before being asked to try solving problems.”
RQ2: The classroom structure from the direct-observations and participant-observations also illustrated how the observers confirmed the organization, the flow of class activities within the different groups, and the structure of the class. Participant Observer # 1 stated: “Class was very organized, the teacher labeled the groups by colors not numbers. There is definitely a routine established by the teacher.”

The teacher had to adjust the lesson plans and find multiple resources to support her differentiated instructional strategies. All resources were available to students and were placed in an organized manner on the teacher’s desk. Participant observer stated: “The teacher organized the classroom in 4 groups setting...the teacher’s desk is a display table for rubrics, activities for students to choose from, and any supplies any student might need for their math class.”

Unfortunately, being the pioneer in exercising differentiated instructional strategies in a secondary mathematics classroom was not helpful either. The researcher had to look for resources and provide students with the most conducive options that would cater to their needs. As the reader might imagine, this process did not evolve overnight. It exhausted many hours of labor and good organization skills to accomplish.

**Quantitative evidence.** Participants from families B, C, and D all provided positive feedback about the classroom structure with the exception of one participant in family A. This may relate to the lack of confidence this particular student had in the teacher, herself, or her team-members. The student kept on repeating that she did not appreciate how each group was working on different problems. She was not sure if what she was working on was compatible to what other students were engaging in. The student might have been accustomed to direct instruction; therefore, it was hard to adjust to a
revamped structure that was imposed on the class. However, thinking about the unknown should not hinder educators from embarking on a change that promises to help students grow and develop.

Discussion of classroom structure. RQ1: The researcher did not anticipate any student to be apprehensive to the change of classroom structure. However, one student lacked the appreciation for the new classroom structure. Participant #24 stated: “I like working alone so I like doing the activity sheets by myself. As I am writing this I am sure everyone is saying they like this teaching style more than last year’s, but I actually like lectures.” This may relate to the mind-set a traditional student is accustomed to in a traditional mathematics class where the responsibility is solely on the teacher. However, in a differentiated classroom, there was a shift of responsibility to both teacher and student. Therefore, having apprehensive students in the new classroom structure is a common phenomenon. The literature discussed that this phenomenon is difficult to change. Fullan (1991) stated:

Change is difficult because it is riddled with dilemmas, ambivalences, and paradoxes. It combines steps that seemingly do not go together: to have a clear vision and be open-minded; to take initiative and empower others; to provide support and pressure; to start small and think big; to expect results and be patient and persistent; to have a plan and be flexible; to use top-down and bottom-up strategies; to experience uncertainty and satisfaction. (p. 350)

RQ2: From the researcher’s point of view: Though there was no blueprint for change, and the fear of change should not impede reaching the goal of improving teaching and learning. These findings confirm Tyler’s (1949) rationale and Callahan’s
(1999) discussion of curriculum and standards. Furthermore, Tomlinson (2000) explained when teachers are differentiating the process of delivering knowledge to their students based on a variety of instructional and management strategies, such as small group instruction, the students will thrive in class and develop an appreciation for the discussed material. The process of appreciation may take a while, but it was clearly attainable. The result in this case study, clearly presented 100% of participants in families B, C, and D, and 95% of participants in family A, rated their experience in a differentiated classroom as positive.

**Challenging material.**

*Qualitative evidence.* RQ1: The data analysis revealed that students enjoyed the challenge of new material and how it was presented to them. For example, participant # 1 stated: “*Though the subject is more difficult this year, I enjoy the challenge.*” Students were more engaged in the different lessons and motivated to learn via the challenge that was imposed on them. Twenty-nine participants appreciated how they had to think on their own to solve problems. Participant # 10 stated: “*I am motivated to learn by solving problems and being challenged. I like going over things on the board and in groups.*” The direct-observations, participant-observations, and survey-interview questions confirmed that challenge existed and acquiring knowledge was a hard task, but definitely within reach. Even the one participant from family A, who did not appreciate the new classroom structure, valued the challenging material. Participant # 24 stated, “I enjoy the challenging material, but I still think lectures are geared more towards my abilities than the classroom activities.”
RQ2: When the teacher was developing differentiated units, she was thinking about the students and their needs. Preparing lesson plans and keeping students’ different profiles in mind became one entity. The process of designing lesson plans shifted from one lesson that discusses few learning objectives to multiple lessons that discuss the same objectives; however, the tiering of activities and sample problems were completely different. Direct observer #1 stated: “All working on quadratic versus linear equations, but at varying levels of sophistication...” This process was time consuming and very demanding for the teacher.

**Quantitative evidence.** The quantitative data analysis of primary documents disclosed all participants from all different families A, B, C, and D enjoyed the challenging material. The direct-observations data analysis (4.2.2) showed that the two observers confirmed that students were placed in different groups based on their competency levels, they were engaged, and they were motivated to work on the presented material.

The survey-interviews analysis (4.3.1- C) illustrated that 67% of participants found the material to be just right, 20% found the material too difficult, 10% found the material too easy, and 3% found the material sometimes difficult for them, yet they enjoyed the experience and the challenge bestowed upon them.

**Discussion of challenging material.** RQ1: The literature review discussed how students in a differentiated instruction classroom would be engaged in challenging material at their appropriate competency levels, which would increase their conceptual understanding of the material and their ability to demonstrate their understanding. For example direct observer # 2 stated, “I observed students with a history of not
participating in class becoming engaged with their peers and I observed students who struggle to stay-on task remain focused and eager to work through the tasks.”

The result of the challenging material relates to Tomlinson’s (2000) discussion of how teachers could differentiate the product according to the student’s learning profile. Therefore, the varied questioning strategies and the complex instruction would only benefit students as proven by the data analyzed in this case study.

RQ2: Furthermore, the researcher discussed how Vygotsky (1978) explained the importance of challenging students within their zone of proximal development, as determined through problem solving under adult and peer guidance. Thus, the teacher had to remain cognizant about the level of challenge she was imposing on her students for the challenge not to be counter-effective. Consequently, teacher’s attitude and design of differentiated units was an exciting yet demanding process. As stated by the participant observer: “The teacher counted for all the variables she could think of ahead of time to minimize the disruption in class and maximize the chances for growth and development. Each lesson plan was four lesson plans now. Each project was four different projects.” The teacher had to keep each student in her mind as she was designing the lessons. As discussed by Tomlinson (2001) teachers will empower their students and maximize their achievements by designing lessons that work for individual learners.

Group problem solving.

Qualitative evidence. RQ1: The data analysis in chapter IV presented how participants were always working in groups of compatible. For example, direct observer # 2 stated: “Her class [Mrs. Ariss’s] was divided into four tiers, and students were given specific group work that aligned with their current knowledge of the material.” Based on
students’ performance on the pre-assessment, the teacher placed students in their compatible groups. In the primary documents of participants’ journal reflections, the direct-observations, and the participant-observations, students expressed their agreement in the collaboration occurring in groups. Some students mentioned the need for compatible group work in different discipline areas, too. For example, participant # 4 stated, “It would be nice to keep the groups constant among all classes. It is so fun working with people at your level.”

The students evidently felt the sense of ownership of their education, appreciated their peers’ skills, and seized the time to discuss the problems with their team members, which increased their interest in learning the subject. Participant # 2 stated: “We are depending on ourselves so we understand better and create a stronger connection with each other.” Participant # 5 stated: “I am actually thinking about the problems and how to solve them rather than here is how you do the problem.”

RQ2: As the researcher was implementing the new differentiated instructional strategies and concentrating on group problem solving, the researcher did not anticipate that some students might not be willing to collaborate. For example, direct observer # 1 stated: “E’s group was divided – the two sides of the table didn’t talk to each other much at all.” Therefore, the researcher had to establish some norms and a checklist for students in each group to periodically have them check on the collaboration within the group (Appendix J). The two direct- observers helped brainstorm some ideas to support the researcher with this emerging demand.

Quantitative evidence. Regarding the data provided for question one in the survey-interview: How often do you work in groups, all 100% of the participants
provided the same reply as, “all the time.” Though the majority, 77%, of participants felt their group members changed most the time, there were 17% of participants who stated their group members almost never changed. By analyzing the data further, the participants who belonged to the 17% discussed above were either from the lowest tier or the highest tier. As the reader might predict, there is always a group of people that remain constant almost all of the time who lack the foundation of the subject matter. Similarly, there is always a group of students that will remain constant almost all of the time who are very competent in the subject matter.

**Discussion of group problem solving.** RQ1: The result of group problem solving associated with Vygotsky’s (1978) social development constructivist theory where social interaction is a vital process for learning and improvement. The finding related to Jensen’s (1995) discussion of it being important to focus, allowing students to perceive a solution as possible, to have multiple resources to solve a problem, to have control over the situation, and to ensure sufficient time for learning.

RQ2: The findings relate to Tomlinson’s (2000) discussion of differentiating instruction to accommodate students’ readiness levels, where the teacher adjusted the degree of difficulty for a task to meet the student at an appropriate level. Developing differentiated units was *not* an easy task on the teacher. To accomplish this demanding task, teachers need enough time to prepare, organize, and identify contexts that are developmentally appropriate for learners. Therefore, as a *preliminary* step, the teacher had to identify abundant and accurate resources to support the designed lessons. Some resources the teacher used are: *Advanced Algebra II* by Prentice Hall, *Algebra II Common Core* by Pearson, and Kuta Software.
Individual attention.

**Qualitative evidence.** RQ1: The data analysis of the primary documents as presented in students’ journal reflections showed students valued the individual attention they received in class. For example, participant # 15 stated: “I like the group aspect of sitting with people that struggle with similar things. It allows me to have a more centered learning on specific problems and concepts.” Though the teacher was rotating among groups, students regarded the time spent with them in their small group as fun and beneficial. Participant # 15 stated: “When we all struggle with the same types of problems and Mrs. Ariss help us by working with us directly when we are struggling...”

The direct-observations and participant- observations discussed the teacher’s attitude as being a member of the group. Direct observer # 1 stated: “The teacher working with the students at the same table, making sure to rotate among the different groups as needed.” Furthermore, the teacher’s approach towards students and the subject made it more enjoyable for the students to learn and grow.

RQ2: In a differentiated instruction classroom, the teacher is expected to work individually with students. The direct-observers and the participant-observer noted that the teacher was working closely with the different group members at their tables. Though the teacher expected some students to reflect negatively on this experience and categorize it as a daunting experience, she observed how fast students adapted to having her work with them at their table. Participant observer stated: “I have to admit some students were intimidated by my presence with them at the same table in the beginning but they adjusted faster than expected.”
Students clearly enjoyed the individual attention they were getting and the teacher enjoyed knowing the exact difficulties students were attempting to overcome. For example participant # 30 stated: “It is easier to get individual help in a small group rather than the whole class.”

Quantitative evidence. The quantitative data analysis, for the 30 students participating in this case study, revealed that 21 students scored in the A range, four students scored in the B range, four students scored in the C range, and only one student scored in the D range. The sample mean was 90.46%, which is extremely high for such a demanding subject. The averages are a clear indication of the benefits of individual attention during the classroom experience.

Discussion of individual attention. RQ1 & RQ2: These findings connected well with Kaufeldt’s (1999) argument about students and teachers working collaboratively to make sense of the discussed material in class and Tomlinson’s (1999) discussion of becoming partners with students to increase the achievement levels of students. In the differentiated instruction classroom, teachers and students were engaged in reflective conversations and experiences, which promoted meaningful teaching and learning. The teacher enjoyed the experience and getting to understand students, in smaller group setting, was rewarding to her, for she had the opportunity to consider all her students’ struggles and appreciate all their talents.

Lectures.

Qualitative evidence. RQ1: The data analysis of the primary documents as presented in students’ journal reflections illustrated that the majority of students appreciated the lack of lectures and being talked at. Students valued how they were asked to think and
solve problems rather than the teacher doing the problems for them. Participant # 1 stated: “It is so fun working with people at your level and having the teacher working with you directly rather than lecturing everyone the same material.” The process of receiving knowledge in this differentiated classroom was a total shift in comparison to previous years. For example, participant # 16 stated: “I appreciate the fact that in this math class there aren’t any lectures.” However, one student did not value the lack of lectures; she expressed her concerns saying she’d rather receive a lecture, then complete sample problems. Participant # 16 stated: “Last year, math class included a lot of notes and the teacher standing in front of the board. I found that I definitely enjoy being able to take notes and see examples before trying a problem.”

RQ2: The direct-observations and participant-observations discussed how the teacher was guiding and facilitating the learning and teaching rather than doing the work for students. Direct observer # 1 stated: “Laila’s questions to the lower tier groups are specific and aimed at helping students move through the process of working a problem—asking students to explain their thinking process to her.” The researcher did not anticipate that any student would prefer lectures and note-taking over group and individual thinking processes; therefore, having one apprehensive participant was an eye opening experience for the researcher. Teachers who are planning to adopt differentiated instruction in their classrooms might want to survey students and ask them about their learning styles and may consider shifting periodically between direct and differentiated instruction.

Quantitative evidence. The quantitative data revealed that students thrived in class. The final semester average for these two groups and the median of the data were
90.46% and 93% respectively, which are considered extremely high for a math class based on the researcher’s experience for over a decade. Therefore, students clearly demonstrated the learning of the material with the absence of lectures and the monotonous routine.

**Discussion of lectures.** RQ1: The conclusion of this section about lectures and students’ performance outcomes connected with the literature review as Engelmann et al. (1988) discussed how effective teachers know learners are different and that doing more is not necessarily challenging learners. There are great teachable moments when details and outcomes are not calculated.

RQ2: Similarly to Engelmann et al. (1988), Tomlinson (1999), Willis (2006), Gregory et al. (2013), and Beck (2001) discussed how teachers expected students to adjust to their teaching style rather than the teacher adjusting to different learners. As such, in a differentiated classroom the teacher was expected to adjust to the diverse population. The teacher’s passion towards the subject and attitude towards the students, as described by the direct-observers and the participant-observer, illustrated what type of teaching occurred inside the classroom. As a result of differentiated instruction, students were: responding favorably to the subject matter, cooperating with a positive attitude, and expanding their horizons to express their creativity.

**Motivation.**

**Qualitative evidence.** RQ1 & RQ2: The data analyses of the primary documents as presented in students’ journal reflections reflected that the majority of students were motivated to do the work. Some factors students mentioned relating to their motivation were: the challenging material, the groups’ dynamics, and classroom structure. For
example, participant # 12 stated: “the structure, organization, and the environment in all helped me stay focused and motivated to learn.”

The direct-observations and participant-observations discussed how the teacher was able to keep students focused, engaged, and eager to learn in class. Allowing students to express their learning via different avenues that related to their interests and multiple intelligences definitely helped students stay engaged. Physical artifacts students provided were a clear indication of their engagement in the discussed material. For example, participant # 20 stated: “I guess it is the pace of the material and the challenge in the problems are the reasons for keeping me motivated to learn in this class.”

**Quantitative evidence.** The quantitative data presented a high semester average and students enjoying the experience regardless of their average. For example, participant # 1 who scored in the D range stated: “I enjoy the style of teaching and the subject much more than last year’s Geometry. Though the subject is more difficult this year, I enjoy the challenge. I think we should keep the groups because they are really cool.” Though a reader might expect the D and C family to display lack of motivation towards the subject, yet, their feedback demonstrated positive feedback. For example, participant # 10 stated: “I am motivated to learn by solving problems and being challenged a little.” Therefore, approximately all students were clearly motivated to learn.

**Discussion of motivation.** RQ1: These findings connected well with Gardner’s (2006) argument about the importance of varying instruction in class and catering to students’ learning profiles to keep them motivated and engaged. In a differentiated classroom, teachers reflect on multiple intelligences when designing their lesson plans. As mentioned in (4.2.1 - C), lesson plans included activity sheets and projects that
touched on different intelligences. When a lesson or an activity is designed to match the intrinsic ability of students, students embrace the material and apply the acquired skills to different settings they might encounter. Thus, they create products (physical artifacts) that are unique to their abilities.

RQ2: The teacher acknowledged that students were motivated to rise to her expectations as she orchestrated her lesson plans to accommodate their interests and learning profiles. Knowing students’ learning profiles and allowing them to differentiate their products contributed to the success of the students involved in this case study. Offering students the freedom of choice to express their learning is what Tomlinson (2000) described as differentiating the process of how students come to understand and make sense of the presented material. As the reader might know, accommodating students’ needs by differentiating the process of designing lessons was not an easy task on the teacher to accomplish; however, the significant success of the students was worth the effort.

Lack of peer pressure.

Qualitative evidence. RQ1: The data analysis revealed that students enjoyed how their peers in class did not judge them. Participant # 5 stated, “I feel I can ask questions and my team members are not going to laugh at me.” It is often the case when a teacher is doing direct instruction that some students might shy away from asking questions due to fear of being looked at as “incompetent.” The students felt comfortable asking their peers questions and their teacher as they work collaboratively in small groups. For example, participant # 1 stated: “Placing us in groups where we can work at our own pace and not feel stressed because of other students.”
The primary documents of students’ journal reflections, direct-observations, and participant-observations confirmed that students were relaxed and enjoyed the “stress-free” environment established in class. For example, participant #21 stated: “We are placed in similar groups so no one is judging others.” Direct observer #2 stated, “More specifically, Mrs. Ariss would work with students in these two tiers [1 and 2] by chunking the material and explaining the concepts in more detail.” Participant observer stated, “Students were relaxed and enjoying the work provided to them.”

RQ2: Data analysis of the nurturing environment, as stated in participant-observations, illustrated the many factors that helped create a stress-free zone for students to succeed in. The teacher’s goal was to establish such an environment in class to help students maximize their learning. Having clear expectations and rules in class helped the students adapt fast to new expectations and fostered a nurturing environment for all participants to thrive in. For example participant #12 stated: “I like the structure, organization, and the environment in all helped me stay focused and engaged.”

Quantitative evidence. Data analysis across the different categories proved that the overall experience was positive for the majority of the students regardless of their letter semester average in the course. Even though 20% of participants reported the material was too difficult for them, they had a positive experience in class. Not one participant reported negative feedback about being stressed or pressured in the differentiated instruction classroom.

Discussion of lack of pressure. RQ1: The result of this section connected to the literature review as discussed in Maslow’s (1968) hierarchy of needs; meeting students’ needs and creating a safe environment for all to learn decreases stress and boosts
progress. As a result of having a differentiated instruction classroom, students maximized their progress and enhanced their learning. Similarly, Tomlinson (2000) explained when teachers differentiate their instruction in response to students’ readiness levels by adjusting the degree of difficulty of tasks; students’ comprehension and appreciation of the subject would be enhanced.

RQ2: The researcher acknowledged that when students are working in groups of compatible levels negative judgments rarely occur. Likewise, Jensen’s (1995) discussed the importance of a relaxed environment for the brain to grow and develop. In the same time, when students are advanced in their skills and their needs for being challenged are not met in class, they may lose interest and lack the motivation to work. Therefore, creating a safe environment that is stress-free for all students is a vital part for classroom learning.

Student’s task.

Qualitative evidence. RQ1: The data analysis of primary documents, direct-observations, participant-observations, and lesson plans revealed that students were able to accept their task in class, which can be summarized as: working on problems collaboratively with their team members, accepting the notion of thinking on their own contrary to someone at the board doing the thinking for them, asking clarifying questions when needed, and connecting the math concepts to formulate a cohesive understanding of the material rather than isolated topics with no connection. The majority of students felt empowered and in charge of their learning, and they clearly enjoyed the experience as proved by the collected data. For example, participant # 2 stated: “I enjoy how we learn from experience and from each other.”
RQ2: As part of students’ tasks, they were to work with their team members to determine solutions for various problems that were assigned to each team. The researcher’s goal with this task was to encourage students to think on their own and with their team members to attempt solving problems based on previous knowledge and material provided to them in class. The researcher made sure to explain the expectations and to set norms and routine in class before embarking of this huge shift in teaching and learning. For example, participant # 22 stated, “I need help, you are always there to answer our questions not directly because you want us to think. I think that is why I am learning a lot this year, because you force us to use our brain, this helps me a lot and I appreciate it.”

*Quantitative evidence.* Data analysis across the different categories proved that the overall numerical outcome for students was in the A range, which proves that contextual teaching and learning is empowering to students. Even the student who reported that she did not appreciate the shift in teaching, ended the semester with an A range. Therefore, teaching and learning were transpiring in the classroom.

*Discussion of student’s task.* RQ1: The finding of this section related to Chiarelott’s (2006) discussion of the importance of contextual teaching and learning and students’ acquisition of knowledge. Engaging students in active learning and enabling them to have opportunities to direct their own learning is a powerful tool for a deeper understanding of the material.

RQ2: Likewise, Tyler (1969) discussed the importance of considering education an active process where learners are actively involved in their learning to maximize their
skills and apply and demonstrate their comprehension. Therefore, the researcher’s experience was satisfying as students were motivated and mindful about learning the material.

**Teacher’s role.**

**Qualitative evidence.** RQ1 & RQ2: The data analyses across all categories were consistent in explaining the teacher’s role in the classroom. The teacher’s role as seen by the direct-observers, the students, and the participant-observer can be summarized as: working with students in small groups, facilitating the teaching of math, guiding students to learn the material, and encouraging students to think and use their logic while solving problems. For example, participant # 18 stated, “I like how the teacher actually helps you think about math rather than doing the math for you.”

The teacher had neither a table to sit at nor a board to teach at. She was always rotating among the different groups and guided them through the material rather than doing the math for them. For example, participant # 23 stated, “She always tries to understand why we are struggling and where then she helps guiding us through.”

Therefore, it was hard for some students to accept the radical shift in the teacher’s role, except they adjusted faster than the researcher anticipated. For example, participant # 17 stated, “It was tough in the beginning not seeing the teacher leading class lectures and showing us how to do problems, but towards the end I enjoyed the different groups I worked with and the challenges I had to face and think about.”

**Quantitative evidence.** The quantitative data presented in this case study proved that the students mastered the material and were able to demonstrate their understanding by the different projects they delivered and the multiple assessments they took.
Therefore, learning was transpiring without the teacher standing in front of the class at
the board feeding knowledge to students.

**Discussion of teacher’s role.** RQ1: The findings of this section relates to the
literature review as Leinwand (2014) argued that excellent mathematics teaching engages
students in a collaborative and meaningful experience that promotes the ability to think
and reason mathematically, as this process promoted an intellectual growth and structure
of knowledge formation with learners. As proven by the qualitative data, students
enjoyed the experience of thinking and analyzing the material within their small group,
and the quantitative data presented a higher retention of the material in comparison to
previous years.

RQ2: There was a definite shift in the role of the teacher in a differentiated
instruction classroom. The teacher had to step back and listen to students’ inquiries and
analyses of the problems they were attempting to solve. It would have been easier for the
teacher to provide answers and demonstrate solving strategies for learners; however, the
literature review discussed the importance of developing learners’ critical thinking skills.
Tomlinson and Demirsky (2000) argued that a teacher’s role in a differentiated classroom
can be described as actively and positively guiding and helping students learn the
material. Furthermore, in a differentiated instruction classroom, teachers are an essential
part of all groups because they are the facilitators of learning. Through the support and
guidance teachers provide to different groups, students prosper and succeed.

**Teaching style.**

**Qualitative evidence.** RQ1: The data analysis of the primary documents, direct-
observations, participant- observations, and the way the teacher prepared her lesson plans
presented a common theme for teaching style: cooperative partnership between the teacher and students. The teacher, as described by all constituents in this study, used time flexibly to address all her students’ needs. She used a wide range of instructional strategies and became a partner with her students. According to the qualitative data, students enjoyed the teaching style bestowed on them. For example, participant # 19 stated: “The teaching style is more collaborative and the teacher is working with you in your group.”

RQ2: The teacher made sure to provide an environment that is conducive to learning for all students. As illustrated by students’ and observers’ feedback, the atmosphere was engaging and supportive. Therefore, the learning environment was shaped to support the students and their learning. Students appreciate being in a positive environment as educators do. For example, participant # 22 stated: “I like the variety in the problems and the different teaching style. I like how you can work with us on the same table and discuss the problems with each group separately.” Therefore, all constituents in this study valued this experience.

*Quantitative evidence.* The quantitative data presented in this case study, in the form of final semester averages, demonstrated that the students grasped the material and were able to validate their understanding by the different projects they delivered and the multiple formative assessments they took. Therefore, learning occurred when the teacher became a partner with students.

*Discussion of teaching style.* RQ1: The findings of this section associate well with Jensen’s (1995) discussion of the importance of creating the right climate for the...
brain to develop and flourish. The teaching style and the varied instructional strategies were regarded as positive when students’ realized how to solve problems independently.

RQ2: As Tomlinson (2000) explained how educators’ emphasis on quality curriculum should not focus on covering the learning objectives of lessons; it should take into consideration engaging students in their learning in order for students to demonstrate a successful understanding of the material. From the teacher’s perspective, the path of educating students in a differentiated instruction classroom was not a smooth one, however, persistent effort and courage to embrace the change required was worth the experience. As stated by participant # 7: “My first algebra experience was not very good, but this class is making up for it. Better teacher and style.”

Tiered groups.

Qualitative evidence. RQ1 & RQ2: The data analysis of primary documents, direct- observations, and participant-observations revealed that students enjoyed working in tiered groups as this allowed them to work on their challenges within a smaller group. For example, participant # 7 stated: “Being in groups of compatible level and having activities that are different than other groups in the same class makes me feel that the instruction is geared towards my abilities.” Direct observer # 2 described the class: “During Mrs. Ariss’s algebra 2 class, I observed differentiated instruction through tiered groups, in which students were organized by their performance on a pre-assessment.”

This, in turn, provided the teacher an opportunity to address students’ readiness levels in a smaller and more efficient setting. The lesson plans and activities the teacher designed for each level were beneficial and encouraging to all students. Thus, their overall experience in a differentiated instruction classroom was positive. Participant # 8
stated: “The instruction is geared towards my abilities when we get put into groups often with people with the same ability as myself, so that would help me when working together.”

**Quantitative evidence.** The quantitative data analyzed in chapter IV proved that students mastered the material and were able to demonstrate their understanding by different projects they delivered and multiple assessments they adhered. Therefore, learning was transpiring at a higher rate (given the high sample mean, 90.46%) as a result of placing students in tiered groups.

**Discussion of tiered groups.** RQ1 & RQ2: Teachers in differentiated classrooms accept and act on the premise that they must be ready to engage students in instruction through different approaches to learning, by appealing to a range of interests, and by using varied rates of instruction along with varied degrees of complexity and support systems. The findings of this section connected with Tomlinson’s (2000) argument that teachers can ensure students competing against themselves as they grow and develop more than competing against one another, always moving toward—and often beyond—designated content goals. Aligning key skills and material form the curriculum with topics that intrigued the interest of students, supported students to maximize their learning experiences.

**Work at own pace.**

**Qualitative evidence.** RQ1 & RQ2: The data analysis of primary documents, direct-observations, and participant-observations revealed that students enjoyed working at their own pace. It allowed them to clear any perplexity of the conceptual understanding of the material and focus on their needs to further improve their skills.
Addressing their interests and compacting the curriculum when needed were all factors in helping students appreciate the learning and the experience in a differentiated classroom. Participant # 18 stated: “It is amazing how we all have different abilities and we work at our own pace and gain the same knowledge at the end.”

Quantitative evidence. Quantitative data analysis of students’ performance outcomes was skewed to the left. Thus, the results were relatively high in comparison to a normal bell curve shape of data. Therefore, collected data conferred high achievement scores for students. Participant # 8 stated: “Last year the pace and the teaching style were different. This year I am learning and retaining the information much easier.”

Discussion of work at own pace. RQ1 & RQ2: The findings of this section associated with Tomlinson’s (2000) and Gregory’s et al. (2013) discussions about the need for teachers to address the readiness levels of students in class and the importance of grouping students at same competency level, where tasks and material assigned are challenging yet attainable.

Students’ achievement level clearly increased with adjusting the degree of difficulty for the different tasks and providing appropriate levels of challenge for each group.

Conclusion of the Study

In conclusion, the qualitative data in this study supported the quantitative data findings and illustrated various possibilities for teachers to implement differentiated instructional strategies in their classrooms. The qualitative data analysis revealed different components of differentiated instruction classrooms and their effects on both: the students and the teacher. The teacher modeled Tomlinson et al.’s (2006) design of a differentiated classroom, where she pre-assessed students, placed them in compatible
competency level groups, differentiated instruction based on process, product, and content according to students’ learning profiles, interests, and readiness levels. With the many changes that were imposed on students, for example: classroom structure, teacher’s role, students’ task, small group setting, collaborative work in tiered groups, and lack of lectures, students acclimated and embraced the changes enthusiastically and swiftly. The majority of students reported positive reflections describing their experience in a differentiated instruction classroom. The quantitative outcome of this study was positively related to the qualitative experience of students as described in their journal reflections. Data were skewed to the left, which indicated that the majority of students performed above average. Students from the bottom two quartiles, where the D and C averages were dominating, described their involvement in the differentiated instruction classroom as a positive experience.

The teacher’s experience can be summarized as demanding and arduous, nevertheless, gratifying. The teacher spent ample amount of time preparing pre-assessments, lesson plans, activities, projects, and post assessments for each group of students. The teacher had to be very cognizant about returning material and giving constructive and continuous feedback to students. In addition to that, the teacher had to step out of her comfort zone and learn alongside with students. The ambiguity of the unknown in classroom structure, the shift of power allocation of acquiring knowledge from the teacher to students, and the aspiration to create a successful experience for students to intellectually grow and develop were all factors the teacher was constantly considering and thinking about.
From the teacher’s perspective the qualitative data the students and direct-observers provided were valuable as tools to assess the teacher’s actual performance in class in relation to a theoretical understanding and application of a new trend in education. Giving students’ choices, allowing for interactive learning, challenging students at different levels, working with students in smaller groups, and devoting individual attention to each student were all original to the teacher and proved to be successful approaches to teaching and learning.

The quantitative data analyses were surprisingly impressive. The analysis displayed 70% of participants scored in the A range, 13.33%, rounded down to 13%, of participants scored in the B range, 13.33%, rounded down to 13%, of participants scored in the C range, and 3.33%, rounded approximately to 3%, scored in the D range. After almost 13 years in the field of education, the teacher never had such high averages in such a demanding subject. Therefore, the teacher classified the results as successful and she embraced differentiated instruction in all of her classes.

Through the use of qualitative and quantitative data analyses, using ATLAS.ti and Microsoft Office Excel, and the existing research on differentiated instruction, the researcher developed a better understanding of differentiated instruction in action and how it can enhance students’ appreciation of the subject matter, specifically in the mathematics field. Students’ progression in any subject matter continues to be the ultimate goal of educators; therefore, the findings of this study clarified that the students’ and teacher’s experiences with differentiated instruction were positive. Therefore, educators must embrace differentiated instruction with an open-mind set and design
effective teaching strategies in their classrooms where they meet the needs for all students.

**Implications of the Study**

This research study contributes to the literature on students’ experience in a differentiated instruction mathematics classroom. The research was conducted in an authentic classroom setting where the researcher is the classroom teacher. While there are continuous trends and inclinations in the field of education, in any upper school mathematics classroom the direct instruction method of teaching is the dominant model (Tomlinson, 1999). This research contributes to the growing research literature on differentiated instructional strategies and how students’ experiences in a differentiated instruction classroom relate to their performance outcome in class.

Since many educational institutions are embracing differentiated instruction in their mission as a tool to personalize education and maximize students’ intellectual growth and development, researchers call for further investigations of the effects of differentiation on teachers in the classroom (Subban, 2006; James, 2009; Tulbure, 2011).

While there is a growing evidence of teachers’ appreciation of differentiated instruction (Tomlinson, 1995; Tomlinson, 2001; Tomlinson & McTighe, 2006), little is revealed in the research literature about how students and teachers describe their experience in a differentiated classroom. If researchers want to increase students’ comprehension of mathematics, it would be essential to grasp the highlights of their experience in a differentiated classroom that strengthens students’ abilities to demonstrate their comprehension of the knowledge.
Practicing teachers must acquire a solid foundation in differentiated instructional strategies that leads to their competence in the field of teaching. This is extremely important in the field of mathematics as our nation is always under achieving in mathematics and science. Therefore, it is significant that teachers attend professional development workshops that are age and content appropriate for their students, as these professional development opportunities will provide teachers with hands-on activities that stimulate their confidence and encouragement to embrace such a change inside their classrooms.

As this research suggests, with the use of differentiated instruction in upper school classrooms and with more success in students’ performance outcomes, teachers will continue to implement differentiated instruction in their classrooms. This success does not require continuous professional development; in isolation with experience, it requires administration support and an open-mind set for all constituents involved in the process.

The implications of this research for pre-service teachers and teacher training programs is that besides learning pedagogy and the theory behind differentiated instruction, being familiar in designing differentiated instructional strategies lesson plans can further ensure a smooth transition for pre-service teachers to the actual field of education.

Limitations of the Study

Researcher’s bias has been acknowledged in chapter 3; however, it must be added that the researcher is the classroom teacher. Therefore, being the teacher impeded the opportunity to be more thorough with participant-observations log entries. Furthermore,
the researcher could have utilized more technology to capture as many details in terms of students’ interactions and collaboration she may have missed while she was teaching.

This case study was conducted at a college preparatory independent school in the area. The researcher being a faculty member may have skewed the results in a way that could have been different if the same study had been piloted in a mainstream public school in the area with multiple teachers and different classrooms.

**Recommendations for Further Research**

This research was conducted over a period of a semester in an academic school year. There are multiple avenues to further enhance such a research. Some of which are:

1. Doing the research over the whole year and not only one semester to determine if performance outcome would change over a longer period of time.

2. Do similar research for students throughout the four years of high school to explore the trends in their success over an elongated period of time.

3. Similarly, if time and conditions permit, this study would have been optimized if students were to be taught in a direct instruction method then differentiated instruction method to compare and contrast the performance outcome results.

4. Likewise, the benefits of further research where the same students take their standardized tests (ACT and SAT) and determine if differentiated instruction affected their performance outcome.

5. This research was conducted at an elite independent school in the area. Since the topic was mathematics (content-base discipline) an interesting research would be to organize a similar study at multiple schools (urban, suburban, and public) and
complete a cross-sectional analysis to provide information on the processes over time.

6. This research can be further developed in various disciplines to determine if students would still rate their experience as positive as they did in the math class.

7. Furthermore, the researcher could enhance this research by examining the different components of differentiated instruction. For example, differentiating the content, the product, or the process one aspect at a time.

Along with the complexity of designing differentiated units comes the difficulty of the individual variances among teachers. Teachers might be subconsciously biased towards certain topics they teach in their classes, which would diminish students’ creativity and limit the teachable moments. Therefore, further research is needed to measure and overcome those biases.
References


high-quality units. Alexandria, VA: Association for Supervision and Curriculum Development.


## Appendix A

### Upper School Class Rotation Schedule

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 8:15</td>
<td>Arrival</td>
<td>Arrival</td>
<td>Arrival</td>
<td>Arrival</td>
<td>Arrival</td>
</tr>
<tr>
<td>8:15 - 8:35</td>
<td>Assembly</td>
<td>Advisee</td>
<td>Assembly</td>
<td>Advisee</td>
<td>Assembly</td>
</tr>
<tr>
<td>8:35 - 10:00</td>
<td>A</td>
<td>E</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>(85 minutes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10:00 - 10:15</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>10:15 - 11:40</td>
<td>B</td>
<td>A</td>
<td>E</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>(85 minutes)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>11:40 - 12:35</td>
<td>Business Person’s Lunch</td>
<td>Business Person’s Lunch</td>
<td>Business Person’s Lunch</td>
<td>Business Person’s Lunch</td>
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<tr>
<td>(55 minutes)</td>
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<tr>
<td>12:35 - 1:45</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>(70 minutes)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>1:45 - 1:50</td>
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</tr>
<tr>
<td>1:50 - 3:00</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>E</td>
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<tr>
<td>(70 minutes)</td>
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</tr>
<tr>
<td>3:00</td>
<td>Dismissal</td>
<td>Dismissal</td>
<td>Dismissal</td>
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<td>Dismissal</td>
</tr>
</tbody>
</table>
### Enduring Understandings
What big ideas do students need to know by the end of this course?

- Graphs can be used as visual representations to investigate relationships between quantitative data
- Modeling involves identifying and selecting features of a real world situation, representing these features symbolically, analyzing and reasoning the characteristics of a given situation, and considering the limitations of the model.
- Algebraic quantities govern the fluent manipulation of symbols in expressions, equations, and inequalities.

### Essential Questions:
(Approximately 3-6 statements/ideas that are course specific)

- What does change mean? is it important? what can you predict from it?
- How do we analyze and understand patterns, relations, and functions?
- How can verbal, numerical, graphical, and analytical representations be used to solve real world problems?
- What do you do when you do not know what to do?
- How do you identify strategies to use when solving problems?
- How do we develop mathematical conjectures?

### 10-20 Core Concepts and Knowledge:
Students will know

- how to solve equations graphically on their Ti-83 or Ti-84 graphing calculators
- how to use their graphing calculators accurately and effectively
- how to graph and interpret scatterplots
- how to solve systems of linear equations and inequalities
- how the function af(x+b)+c relates to the graph of f(x)

### 10-20 Core Skills:
Students will be able to

- add, subtract, and multiply matrices, with and without a calculator, and solve systems of equations, using 2x2 matrices, by hand, and with 2x2 and 3x3 matrices using the calculator
- Graph and find equations of exponential functions
- Solve exponential function related to interest and exponential growth and decay graphically and by using logarithms
- Perform operations and solve equations with, or
• the properties of logarithms and use logarithms to solve exponential equations
• how to analyze the behavior of functions with and without a graphing calculator
• how to model real world situations with mathematical models
• how to solve problems involving triangles using trigonometry
• properties and graphs of conic sections.

• involving, logarithms and natural logarithms
• Graph and analyze rational functions
• Simplify and perform operations with rational expressions and solve rational inequalities
• Solve problems involving right angle trigonometry, and using Law of Sines and Law of Cosines to solve oblique triangles.
• Sketch graphs of sine, cosine, and tangent, including graphs with shifts and stretches.
• Sketch graphs of conic sections, with analysis involving foci, directrix, lines of symmetry, asymptotes, and shifts.

• solve linear equations and inequalities
• solve linear programming problems
• collect data, make scatter plots and find lines of best fit using their Ti-83 or Ti-84 calculators
• solve systems of equations graphically, algebraically, and with use of matrices
• solve and graph systems of inequalities and absolute value equations and inequalities
• transform functions, including absolute value, quadratic, polynomial, logarithmic, rational, and trigonometric, with shifts and stretches
• use properties of exponents
• factor polynomials, including those requiring long or synthetic division
• analyze graphs of polynomial functions by finding x-intercepts and using sign charts
Appendix C

Sample Artifacts- Students’ Work

2016. 2 Doc # 1: ACROSTIC
THREE FACTS AND A FIB

1. STANDARD FORM: BROKEN DOWN
   (ANY ASPECT COULD POTENTIALLY BE FALSE)
   The standard form of a quadratic equation is written as
   \[ y = ax^2 + bx + c. \]
   Within this equation, the \( a \) value determines the width
   of a parabola. The smaller the number, the wider the
   graph. \( a \) also determines its opening direction.
   Negative values indicate that the parabola opens
   downwards, while positive values indicate upwards.
   \( b \) is present only to convert to vertex form.
   \( c \) is the parabola’s \( y \)-intercept.

2. LINEAR OR QUADRATIC?
   The equation \( y = -x(x + 7) + x^2 \) is quadratic.

3. STANDARD FORM TO VERTEX FORM
   The equation \( y = 2x^2 + 4x + 2 \) is written as \( y = 2(x + 1)^2 - 4 \)
   in vertex form.
   Its vertex is at the point \((-1, -4)\).
   Its axis of symmetry is \( x = -1 \).

4. GRAPHING FROM VERTEX FORM
   The equation
   \[ y = -3.5(x + 2)^2 + 7 \]
   is graphed like so:
   (Vertex shifts 2 units to the left and 7 units up)

FIB REVEALED ON BACK!

2016. 2 Doc # 2: Three Facts and A Fib (Part b)

NUMBER 2 (LINEAR OR QUADRATIC?) WAS THE FIB!

THE EQUATION \( y = -x(x + 7) + x^2 \) IS NOT ACTUALLY QUADRATIC.

In order for an equation to be quadratic, it must possess an \( x^2 \) term, as \( A \) cannot be
equal to zero. At first glance, this specific equation may appear to meet this
requirement. However, once simplified, it no longer contains \( x \) squared. As a result, it
cannot be quadratic. Instead, this is a linear function.

SIMPLIFICATION STEPS:
\[
\begin{align*}
Y &= -x(x + 7) + x^2 \\
Y &= -x^2 - 7x + x^2 \\
Y &= -7x
\end{align*}
\]
2016. 2 Doc # 3: Instruction Cards (Part a)

to put an equation into factored form, you simply just
\[ y = x^2 - x - 6 \]
\[ \frac{y}{(x+2)(x-3)} \rightleftharpoons \text{Factors} \]
\[ y = (x+2)(x-3) \rightarrow \text{Factored form} \]

A polynomial can be written in factored form if you also know its zeros.

The graph of a function with a zero with an even multiplicity will only not zero.

Ex. 
\[ y = (x+2)(x-3)x(x-3) \]
zero \(3,\) multiplicity 0

It is also possible to find functions zeros from the graph.

The zeros of this function are \(-2,0,\) and 2.

There are also things called multiple zeros.

2016. 2 Doc # 3: Instruction Cards (Part b)

**Polynomials and Linear Factors**

Factored Form of a Polynomial

\[ y = x^3 + 5x^2 - 12x \rightarrow \text{NOT in factored form} \]
\[ y = \frac{x+2(3+2)(x-3)}{x+2} \rightarrow \text{polynomial in factored form} \]

The zeros of a function also represent the functions x-intercepts.

When a linear factor in a polynomial is repeated, the zero is repeated. A repeated zero is known as a multiple zero.

-1 is repeated
\[ y = (x+3)(x+3)(x+1) \]

Twice

It could also be said that the zero \(-1\) has a multiplicity of 2.
Appendix D

Sample Lesson Plans

Name: ___________________________ Date: ______________

5.3 Standard and Vertex Form – Green

- Standard form of a quadratic function is \( y = ax^2 + bx + c \).
- Vertex form of a quadratic function is \( y = a(x - h)^2 + k \).
- For a parabola in vertex form, the coordinates of the vertex are \((h, k)\).

Write the equation of the axis of symmetry and find the vertex for each parabola.

36. \( y = 3x^2 - 12x - 2 \)
39. \( y = 3 - x^2 \)
42. \( y = 2x^2 \)

1. You estimate that the ball you hit reached its maximum height of 30 ft about 200 ft from you. Write the equation for the flight of the ball in vertex form. Rewrite the equation in standard form.

Landscaping A town is planning a playground. It wants to fence in a rectangular space using an existing wall. What is the greatest area it can fence in using 100 ft of donated fencing?

Understanding the Problem

1. Write an expression for the width of the playground. Let \( l \) be the length of the playground.

2. Do you know the perimeter of the playground? Explain.

3. What is the problem asking you to determine?

Planning the Solution

4. Write a quadratic equation to model the area of the playground.

5. What information can you get from the equation to find the maximum area? Explain.

Getting an Answer

6. What is the value of \( l \) that produces the maximum area?
7. What is the greatest area the town can fence in using 100 ft of fencing?

G.1
For each function, the vertex of the function’s graph is given. Find the unknown coefficients.

22. $y = x^2 + bx + c; (-4, -7)$

23. $y = ax^2 - 10x + c; (-5, 20)$

24. A local nursery sells a large number of ornamental trees every year. The owners have determined the cost per tree $C$ for buying and caring for each tree before it is sold is $C = 0.001n^2 - 0.3n + 50$. In this function, $C$ is the cost per tree in dollars and $n$ is the number of trees in stock.
   a. How many trees will minimize the cost per tree?
   b. What will the minimum cost per tree be?

6. For the function $y = -5x^2 - 10x + c$, the vertex is $(-1, 8)$. What is $c$?
   - $13$
   - $-3$
   - $3$
   - $13$

13. In your subdivision you have an area planted with wildflowers and trails to walk. To keep the area natural, you want to enclose the largest area possible with 2000 ft of fence. (Assume that the gates are the same width as the amount of fence you use to build them.)
   a. Write an equation for the area $A$.
   b. Find the dimensions of the maximum area.

Write the equation for each parabola in standard form.

47. $y = -3(x - 1)^2 + 4$

50. $y = 3(x + 1)^2 + 6$

53. $y = -(x + 3)^2 - 6$
5.3 Standard and Vertex Form

- Standard form of a quadratic function is \( y = ax^2 + bx + c \).
- Vertex form of a quadratic function is \( y = a(x - h)^2 + k \).
- For a parabola in vertex form, the coordinates of the vertex are \((h, k)\).

2. The profit \( p \) for a country band can be modeled by the function \( p = -25t^2 + 500t - 50 \), where \( t \) represents the ticket price. What would be their maximum profit? What ticket price would bring that profit?

Sketch the graph of each equation. Label each maximum or minimum point and axis of symmetry.

29. \( y = x^2 + 6x + 7 \)
32. \( y = 2x^2 + 12x + 5 \)
35. \( y = x^2 - 6 \)
38. \( y = x^2 - 2x + 5 \)

41. \( y = 2x^2 - 8x - 3 \)
44. \( y = x^2 + 2x - 5 \)

For Exercises 1–6, choose the correct letter.

1. What is the vertex of the parabola \( y = x^2 + 8x + 5 \)?
   - \( A \) \((4, -11)\)
   - \( B \) \((-4, -11)\)
   - \( C \) \((-4, 5)\)
   - \( D \) \((4, 5)\)

2. What is the maximum value of the function \( y = -3x^2 + 12x - 8 \)?
   - \( A \) 4
   - \( B \) -8
   - \( C \) -2

17. Suppose you are tossing an apple up to a friend on a third-story balcony. The height of the apple in feet is given by \( h = -16(t - 1)^2 + 24 \). Your friend catches the apple just as it reaches its highest point. How long does the apple take to reach your friend, and at what height above the ground does your friend catch it?

Graph each function.

7. \( y = x^2 + 2x - 5 \)
8. \( y = -x^2 + 3x + 1 \)
9. \( y = 2x^2 + 4x - 4 \)

Sketch each parabola using the given information.

20. vertex \((4, -2)\), \(y\)-intercept \(6\)
21. vertex \((-3, 12)\), point \((-1, 0)\)
19. A small independent motion picture company determines the profit \( P \) for producing \( n \) DVD copies of a recent release is \( P = -0.02n^2 + 3.40n - 16 \). \( P \) is the profit in thousands of dollars and \( n \) is in thousands of units.
   a. How many DVDs should the company produce to maximize the profit?
   b. What will the maximize profit be?

   For each function, the vertex of the function's graph is given. Find the unknown coefficients.

   22. \( y = x^2 + bx + c; (-4, -2) \)
   23. \( y = ax^2 - 10x + c; (-5, 20) \)

   For each function, find the \( y \)-intercept.

   28. \( y = -(x + 1)^2 + 9 \)
   29. \( y = \frac{1}{2}(x + 4)^2 - 15 \)
5.3 Standard and Vertex Form — Blue

- Standard form of a quadratic function is $y = ax^2 + bx + c$.
- Vertex form of a quadratic function is $y = a(x - h)^2 + k$.
- For a parabola in vertex form, the coordinates of the vertex are $(h, k)$.

Write each function in vertex form. Check.

5. $y = x^2 + x$
6. $y = x^2 + 5x + 4$
8. $y = \frac{3}{4}x^2 + 9x$
9. $y = -2x^2 + 2x + 1$

3. Which function has the graph shown at the right?

- $y = 2x^2 + 3x - 1$
- $y = -2x^2 - 5x + 1$
- $y = 2x^2 + 5x - 1$
- $y = -2x^2 + 5x - 1$

What is the vertex form of the function $y = 3x^2 - 12x + 17$?

- $y = 3(x - 2)^2 + 5$
- $y = 3(x - 2)^2 + 11$
- $y = 3(x - 2)^2 + 17$
- $y = 3(x + 2)^2 + 5$

5. What is the equation of the parabola with vertex $(3, -20)$ and that passes through the point $(7, 12)$?

- $y = 2x^2 + 12x - 2$
- $y = 2x^2 - 12x - 2$
- $y = -2x^2 + 12x - 38$
- $y = 2x^2 - 12x + 38$

6. For the function $y = -5x^2 - 16x + c$, the vertex is $(-1, 8)$. What is $c$?

- $-13$
- $-3$
- $3$
- $13$

15. A skating rink manager finds that revenue $R$ based on an hourly fee $F$ for skating is represented by the function $R = -400(F - 3.25)^2 + 5070$.
What hourly fee will produce maximum revenue?

10. $y = (x - 3)^2 + 1$
11. $y = 2(x - 1)^2 - 3$

12. $y = -3x^2 + 18x - 27$

Graph each function.

10. $y = -\frac{1}{2}x^2 - 3x + 3$

24. A local nursery sells a large number of ornamental trees every year. The owners have determined the cost per tree $C$ for buying and caring for each tree before it is sold is $C = 0.001x^2 - 0.3x + 50$. In this function, $C$ is the cost per tree in dollars and $n$ is the number of trees in stock.

a. How many trees will minimize the cost per tree?
b. What will the minimum cost per tree be?
For each function, find the y-intercept.
26. \( y = (x + 3)^2 - 5 \)
27. \( y = -2(x - 2)^2 + 6 \)

Sketch each parabola using the given information.
20. vertex \((4, -2)\), y-intercept 6 21. vertex \((-3, 12)\), point \((-1, 0)\)

Graph each function.
2. \( y = -x^2 + 3x + 1 \)
10. \( y = -\frac{1}{2}x^2 - 3x + 3 \)
12. \( y = -3x^2 + 18x - 27 \)
5.3 Standard and Vertex Form

- Standard form of a quadratic function is \( y = ax^2 + bx + c \).
  Vertex form of a quadratic function is \( y = a(x - h)^2 + k \).
- For a parabola in vertex form, the coordinates of the vertex are \((h, k)\).

**Example**

Write \( y = 3x^2 - 24x + 50 \) in vertex form.

\[
\begin{align*}
  y &= ax^2 + bx + c \\
  y &= 3x^2 - 24x + 50 \\
  b &= -24, a = 3 \\
  x\text{-coordinate} &= \frac{-b}{2a} = \frac{-(-24)}{2(3)} \\
  &= 4 \\
  y\text{-coordinate} &= 3(4)^2 - 24(4) + 50 = 2 \\
  y &= 3(x - 4)^2 + 2
\end{align*}
\]

---

**Activity**

Write each function in vertex form. Check.

1. \( y = x^2 - 2x - 3 \)
2. \( y = -x^2 + 4x + 6 \)
3. \( y = x^2 + 3x - 10 \)
4. \( y = x^2 - 9x \)

Sketch the graphs of each equation. Label each maximum or minimum point and axis of symmetry.

27. \( y = x^2 - 2x - 3 \)
28. \( y = x^2 + 2x - 6 \)
33. \( y = -3x^2 - 6x + 5 \)

---

2. The profit \( P \) for a country band can be modeled by the function
\[
P = -25t^2 + 500t - 50, \quad \text{where } t \text{ represents the ticket price.}
\]
What would be their maximum profit? What ticket price would bring that profit?
16. A pen is to be constructed alongside a barn using 120 ft of fencing. In order to make the area of the pen a maximum, what should the dimensions of the pen be?

Sketch each parabola using the given information.
20. vertex (4, −2), y-intercept 6
21. vertex (−3, 12), point (−1, 0)

For each function, the vertex of the function’s graph is given. Find the unknown coefficients.
23. \( y = ax^2 - 10x + c; (-5, 20) \)

Sketch each parabola using the given information.
20. vertex (4, −2), y-intercept 6
21. vertex (−3, 12), point (−1, 0)

6. For the function \( y = -5x^2 - 10x + c \), the vertex is (−1, 8). What is \( c \)?
   \( \mathbb{D} -13 \quad \mathbb{D} -3 \quad \mathbb{D} 3 \quad \mathbb{D} 13 \)

For each function, find the y-intercept.
26. \( y = (x + 3)^2 - 5 \)
27. \( y = -2(x - 2)^2 + 6 \)
Appendix E

School Master Calendar

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2015-2016

(Calendar subject to change)

Yearly School Calendar

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Upper School Intensives

- Aug 21 - Sept 11
- Jan 4 - Jan 25
- May 18 - June 8
Appendix F

Tic-Tac-Toe Samples

Comparing Vertex and Standard Forms (Green)
Directions: Check the boxes you plan to complete. They should form a tic-tac-toe across or down. All products are due by:

- [ ] Create a power point presentation that shows different real-world situations that are expressed with quadratic functions in standard and vertex forms. Make sure to include the equations and a clear explanation.

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- [ ] The table below shows the number of cable subscribers in each year.
  a. Find a linear model to represent the data.
  b. Find a quadratic model to represent the data.
  c. Use each model to find the number of subscribers in 2010, 2012, and 2015.
  d. Which model do you think is more reasonable? Explain.

- [ ] Suppose you are tossing an apple up to a friend on the third-story balcony. The height of the apple in feet is given by:
  \[ H = -16(t - 1.2)^2 + 24 \]
  Your friend catches the apple just as it reaches its highest point.
  a. How long does the apple take to reach your friend?
  b. At what height above the ground does your friend catch it?
  Show your work.

- [ ] The graph of the function:
  \[ Y = ax^2 + bx + 8 \]
  Has a vertex at (2, -4).
  a. What is the value of \( a \)?
  b. What is the value of \( b \)?
  c. Graph the function.
  Give two other points on the graph.

- [ ] In your subdivision you have an area planted with wildflowers and trails to walk. To keep the area natural, you want to enclose the largest area possible with 2000 ft of fence.
  a. Write an equation for the area \( A \) as a function of \( w \) or \( A(w) \).
  b. Find the dimensions of the maximum area.

- [ ] As a graduation gift for a friend, you plan to frame a collage of pictures. You have a 9 ft strip of wood for the frame. Use \( L \) for length and \( W \) for the width.
  a. Write an equation to represent the perimeter of the collage in terms of \( W \) and \( L \).
  b. Write an equation for the area in terms of \( W \).
  c. What dimensions of the frame give you the maximum area for the collage?

- [ ] Create a poster board that shows the following:
  a. What is a quadratic function?
  b. What is the standard form of a quadratic function?
  c. What is the vertex form of a quadratic function?
  d. Algebraically explain how to rewrite a standard form in vertex form and vice versa.
  e. What possible misunderstandings/mistakes students might make when dealing with quadratic equation?

Name: __________________ ; Date: ____________________
**Comparing Vertex and Standard Forms**

**Directions:** Check the boxes you plan to complete. They should form a tic-tac-toe across or down. All products are due by: __________

| a. Graph 
  
  \[ y = (x - 3)(x + 2) \]  
  
  b. What points on the graph can you determine from the equation?  
  
  c. Write the equation in part (a) in standard form.  
  
  d. Write the equation in part (a) in vertex form.  
  
  e. Write two other points that lie on the parabola. | b. Design a crossword puzzle that asks questions about all of the important aspects, you have learned so far, of parabolas. Make sure to include an answer key and a clear explanation. | a. The graph of the function: \[ Y = 2x^2 - 6x + c \] has a vertex at (3, 5).  
  
  b. What is the value of c?  
  
  c. Graph the function.  
  
  d. Rewrite the equation in vertex form.  
  
  e. Give two other points that lie on the parabola. |
| --- | --- | --- |
| Design a poster board that shows the algebraic steps used to convert a quadratic equation from vertex form to standard form and vice versa. | **FREE CHOICE**  
  
  [Fill out your proposal form before beginning the free choice!] | Create a picture dictionary for all of the terms used when describing the attributes of a parabola. Make sure to include both formats of any quadratic functions. |
| The graph of the function: \[ Y = 4x^2 - 2x + c \] has a vertex at (1, 2).  
  
  a. What is the value of c?  
  
  b. Graph the function.  
  
  c. Rewrite the equation in vertex form.  
  
  d. Give two other points that lie on the parabola. | Design a crossword puzzle that asks questions about all of the important aspects, you have learned so far, of parabolas. Make sure to include an answer key and a clear explanation. | a. Graph \[ y = (x - 1)(x + 3) \].  
  
  b. What points on the graph can you determine from the equation?  
  
  c. Write the equation in part (a) in standard form.  
  
  d. Write the equation in part (a) in vertex form.  
  
  e. Write two other points that lie on the parabola. |
### Comparing Vertex and Standard Forms (Blue)

**Directions:** Check the boxes you plan to complete. They should form a tic-tac-toe across or down. All products are due by:

<p>| | | |</p>
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<thead>
<tr>
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<tbody>
<tr>
<td><strong>Write each of the given functions in vertex form and graph each equation.</strong></td>
<td><strong>A skating rink manager finds that revenue R based on an hourly fee F for skating is represented by the function:</strong> ( R = -480(F - 3.25)^2 + 5070 ). What hourly fee will produce maximum revenue? Show your work.</td>
<td><strong>Create a product cube that explains different examples of quadratic functions. Include an answer key and a clear explanation for each side.</strong></td>
</tr>
<tr>
<td>a. ( Y = x^2 + 4x + 4 )</td>
<td>b. ( Y = x^2 + 8x + 3 )</td>
<td></td>
</tr>
<tr>
<td>c. ( Y = 2x^2 + 6x + 10 )</td>
<td>Show your work.</td>
<td></td>
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</table>
| **Write each of the given functions in standard form and graph each equation.** | **FREE CHOICE**
(Fill out your proposal form before beginning the free choice!) | **Write each of the given functions in vertex form and graph each equation.** |
| a. \( Y = -2(x - 5)^2 + 40 \) | b. \( Y = -(2x - 3)^2 + 10 \) | a. \( Y = -3x^2 - x - 8 \) |
| c. \( Y = (x + 4)^2 - 4 \) | Show your work. | b. \( Y = x^2 + 7x + 1 \) |
|  |  | c. \( Y = x^2 + 4x \) |
|  |  | Show your work. |
| **Create a set of cards (at least 10) of different examples of quadratic functions that you can use to teach others all about the two formats of quadratic functions. Include an answer key and a clear explanation for each.** | **The profit \( P \) for a country band can be modeled by the function:** \( p = -25t^2 + 500t - 150 \), where \( t \) represents the ticket price. What would be their maximum profit? What ticket price would bring that profit? Explain and show your work. | **Write each of the given functions in standard form and graph each equation.** |
|  |  | a. \( Y = -2(x + 3)^2 + 4 \) |
|  |  | b. \( Y = 2(x + 1)^2 - 3 \) |
|  |  | c. \( Y = 3(x + 1)^2 + 6 \) |
|  |  | Show your work. |
### Comparing Vertex and Standard Forms

**Directions:** Check the boxes you plan to complete. They should form a tic-tac-toe across or down. All products are due by: ___________

<table>
<thead>
<tr>
<th>Write each of the given functions in vertex form and graph each equation.</th>
<th>Explain in details the process of rewriting a quadratic equation in vertex form. Use this equation as the standard form: (3x^2 - 3x + 1). Show all your work.</th>
<th>Create a product cube that explains different examples of quadratic functions. Include an answer key and a clear explanation for each side.</th>
</tr>
</thead>
</table>
| a. \(y = -2x^2 + 4x + 4\)  
b. \(y = 2x^2 + 6x + 10\)  
Show your work. |  |  |

| Write each of the given functions in standard form and graph each equation. | **FREE CHOICE**  
(Fill out your proposal form before beginning the free choice!) | Write each of the given functions in vertex form and graph each equation. |
|---|---|---|
| a. \(y = -(x - 5)^2 + 40\)  
b. \(y = -(2x - 3)^2\)  
c. \(y = (x + 2)^2 + 3\)  
Show your work. |  | a. \(y = x^2 - x - 2\)  
b. \(y = x^2 + 4x + 1\)  
Show your work. |

<table>
<thead>
<tr>
<th>Create a set of cards (at least 8) of different properties or terminologies of quadratic functions that you can use to help your classmates understand this section. Include an answer key and a clear explanation for each.</th>
<th>The profit (P) for a country bank can be modeled by the function: (p = -250t^2 + 500t - 50), where (t) represents the ticket price. What would be the maximum profit? What ticket price would bring that profit? Explain and show your work.</th>
<th>Write each of the given functions in standard form and graph each equation.</th>
</tr>
</thead>
</table>
|  | a. \(y = -3(x - 1)^2\)  
b. \(y = (x + 1)^2 - 2\)  
c. \(y = \frac{1}{2} (x + 2)^2 + 2\)  
Show your work. |  |
Appendix G

Free Choice Activities

All free choice activities were adopted from *Differentiating Instruction with Menus: Algebra I/II* by Westphal, 2013, p. 32-38).

<table>
<thead>
<tr>
<th>Acrostic</th>
<th>Advertisement</th>
<th>Board Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be at least 8.5&quot; by 11&quot;</td>
<td>Must be at least 8.5&quot; by 11&quot;</td>
<td>At least four thematic game pieces</td>
</tr>
<tr>
<td>Must be neatly written or typed</td>
<td>A meaningful slogan should be included</td>
<td>At least 20 colored/thematic squares</td>
</tr>
<tr>
<td>Target word should be written down the left side of the paper</td>
<td>Color picture of item or service should be included</td>
<td>At least 15 question/activity cards</td>
</tr>
<tr>
<td>Each descriptive phrase chosen must begin with one of the letters from the target word</td>
<td>Include price, if appropriate</td>
<td>Include a thematic title on the board</td>
</tr>
<tr>
<td>Each descriptive phrase chosen must be related to the target word</td>
<td>Can be created on the computer</td>
<td>Include a complete set of rules for playing the game</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At least the size of an open file folder</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Book Cover</th>
<th>Brochure/Pamphlet</th>
<th>Bulletin Board Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front cover—title, author, image</td>
<td>Must be at least 8.5&quot; by 11&quot;</td>
<td>Must fit within assigned space on bulletin board or wall</td>
</tr>
<tr>
<td>Front inside flap—paragraph summary of the book</td>
<td>Must be in three-fold format; front fold has the title and picture</td>
<td>Must include at least 10 details</td>
</tr>
<tr>
<td>Back inside flap—brief biography of author with at least five details</td>
<td>Must have both pictures and information</td>
<td>Must have a title</td>
</tr>
<tr>
<td>Back cover—editorial comments about the book</td>
<td>Information should be in paragraph form with at least five facts included</td>
<td>Must have at least five different elements (e.g., posters, papers, questions)</td>
</tr>
<tr>
<td>Spine—title and author</td>
<td>Must provide bibliography or sources</td>
<td>Must have at least one interactive element that engages the reader</td>
</tr>
<tr>
<td></td>
<td>Can be created on computer; images from the Internet must have proper credit</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Sort</th>
<th>Cartoon/Comic Strip</th>
<th>Children's Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must have at least 16 total cards</td>
<td>Must be at least 8.5&quot; by 11&quot;</td>
<td>Must have a cover with book's title and student's name as author</td>
</tr>
<tr>
<td>Should have at least five cards in each column</td>
<td>Must have at least six cells</td>
<td>Must have at least 10 pages</td>
</tr>
<tr>
<td>Can have more than two columns if appropriate</td>
<td>Must have meaningful dialogue that addresses the task</td>
<td>Each page should have an illustration to accompany the story</td>
</tr>
<tr>
<td>Include an answer key</td>
<td>Must include color</td>
<td>Must be neatly written or typed</td>
</tr>
<tr>
<td>All cards must be submitted in a carrying bag</td>
<td></td>
<td>Can be created on the computer</td>
</tr>
<tr>
<td>Class Game</td>
<td>Class Model</td>
<td>Collage</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| • Game should allow all class members to participate  
• Must have only a few, easy-to-understand rules  
• Can be a new variation on a current game  
• Must have multiple questions  
• Must provide answer key before game is played  
• Must be approved by teacher before being played | • Must use all class members in the model  
• Must take no longer than 2 minutes to arrange everyone  
• Students must be able to understand the part they play in the model  
• After the model is created, the explanation of the model should take no longer than 2 minutes  
• Must submit a paragraph that shares how the arrangement of students represents the concept being modeled | • Must be at least 8.5” by 11”  
• Pictures must be cut neatly from magazines or newspapers (no clip art)  
• Label items as required in task |
| Commercial/Infomercial | Collage | Concentration Cards |
| • Must be 1–3 minutes in length  
• Script must be turned in before the commercial/infomercial is presented  
• Can be presented live to an audience or recorded beforehand based on teacher discretion  
• Should have props or some form of costume(s)  
• Can include more than one person | • Must be at least 8.5” by 11”  
• Pictures must be cut neatly from magazines or newspapers (no clip art)  
• Label items as required in task | • At least 20 index cards (10 matching sets)  
• Can use both pictures and words  
• Information should be placed on just one side of each card  
• Include an answer key that shows the matches  
• All cards must be submitted in a carrying bag |
| Cross-Cut Model/Diagram | Crossword Puzzle | Demonstration |
| • Must include a scale to show the relationship between the model/diagram and the actual item  
• Must include details for each layer  
• If creating a model, must also meet the guidelines for a model  
• If creating a diagram, must also meet the guidelines for a poster | • Must include at least 20 significant words or phrases  
• Develop appropriate clues  
• Include puzzle and answer key  
• Can be created on the computer | • Must be at least 2 minutes in length  
• Should show all of the important information from the task statement  
• Must include at least two content-related questions to ask classmates  
• Must be able to answer questions about the topic being demonstrated |
<table>
<thead>
<tr>
<th>Diary/Journal</th>
<th>Dictionary</th>
<th>Diorama</th>
</tr>
</thead>
</table>
| • Must be neatly written or typed  
• Should include the appropriate number of entries  
• Should include a date for each entry if appropriate  
• Should be written in first person | • Must be created in a book format with a cover, a title page, and an about the author page  
• Should include all of the important words needed to address the task  
• Definitions are written in your own words  
• Definitions are easy to understand | • Must be at least 4" by 5" by 8"  
• Must be self-standing  
• All interior space must be covered with relevant pictures and information  
• Name should be written on the back  
• Informational/title card attached to diorama  
• $1 contract signed |

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Essay</th>
<th>Flipbook</th>
</tr>
</thead>
</table>
| • Must be at least 8.5" by 11"  
• Must show what is requested in the task statement  
• Must include color  
• Must be neatly drawn by hand  
• Must have title  
• Name should be written on the back | • Must be neatly written or typed  
• Must cover the specific topic in detail  
• Must be at least three paragraphs  
• Must provide bibliography or sources, if appropriate | • Must be at least 8.5" by 11" folded in half  
• All information or opinions should be supported by facts  
• Must be created with the correct number of flaps cut into the top  
• Color is optional  
• Name should be written on the back |

<table>
<thead>
<tr>
<th>Folded Quiz Book</th>
<th>Game Show</th>
<th>Greeting Card</th>
</tr>
</thead>
</table>
| • Must be at least 8.5" by 11" folded in half  
• Must have at least 10 questions  
• Must be created with the correct number of flaps cut into the top  
• Questions should be written or typed neatly on upper flaps  
• Answers should be written or typed neatly inside each flap  
• Color is optional  
• Name should be written on the back | • Needs an emcee or host  
• Must have at least two contestants  
• Must have at least one regular round and one bonus round  
• Questions should be content specific  
• Props can be used, but are not mandatory | • Front—colored pictures, words optional  
• Front inside—personal note related to topic  
• Back inside—greeting or saying must meet product criteria  
• Back outside—logo, publisher, and price for card |
<table>
<thead>
<tr>
<th>Instruction Card</th>
<th>Interview</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Must be no larger than 5&quot; by 8&quot;</td>
<td>• Must have at least eight questions about the topic being studied</td>
<td>• Must be neatly written or typed</td>
</tr>
<tr>
<td>• Must be created on heavy paper or index card</td>
<td>• Person chosen for interview must be an &quot;expert&quot; and qualified to provide answers</td>
<td>• Uses proper letter format</td>
</tr>
<tr>
<td>• Must be neatly written or typed</td>
<td>• Questions and answers must be neatly written or typed</td>
<td>• Must be at least three paragraphs in length</td>
</tr>
<tr>
<td>• Uses color drawings</td>
<td></td>
<td>• Must follow type of letter stated in the menu (e.g., friendly, persuasive, informational)</td>
</tr>
<tr>
<td>• Provides instructions stated in the task</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Map</th>
<th>Mind Map</th>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Must be at least 8.5&quot; by 11&quot;</td>
<td>• Must be at least 8.5&quot; by 11&quot;</td>
<td>• Includes at least 10 pieces of related information</td>
</tr>
<tr>
<td>• Includes accurate information</td>
<td>• Uses unlined paper</td>
<td>• Includes color and pictures</td>
</tr>
<tr>
<td>• Includes at least 10 relevant locations</td>
<td>• Must have one central idea</td>
<td>• Includes at least three layers of hanging information</td>
</tr>
<tr>
<td>• Includes compass rose, legend, scale, and key</td>
<td>• Follows the &quot;no more than four&quot; rule: no more than four words coming from any one word</td>
<td>• Hangs in a balanced way</td>
</tr>
<tr>
<td></td>
<td>• Must be neatly written or developed using a computer</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model</th>
<th>Mural</th>
<th>Museum Exhibit</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Must be at least 8&quot; by 8&quot; by 12&quot;</td>
<td>• Must be at least 22&quot; x 54&quot;</td>
<td>• Should have title for exhibit</td>
</tr>
<tr>
<td>• Parts of model must be labeled</td>
<td>• Must contain at least five pieces of important information</td>
<td>• Must include at least five &quot;artifacts&quot;</td>
</tr>
<tr>
<td>• Should be in scale when appropriate</td>
<td>• Must have colored pictures</td>
<td>• Each artifact must be labeled with a neatly written card</td>
</tr>
<tr>
<td>• Must include a title card</td>
<td>• Words are optional, but a title should be included</td>
<td>• Exhibit must fit within the size assigned</td>
</tr>
<tr>
<td>• Name should be written on the model</td>
<td>• Name should be written on the back</td>
<td>• $1 contract required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No expensive or irreplaceable objects should be used in the display</td>
</tr>
<tr>
<td>News Report</td>
<td>Newspaper Article</td>
<td>Play/Skit</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>--------------------------------------------------------------</td>
</tr>
<tr>
<td>• Must address the who, what, where, when, why, and how of the topic</td>
<td>• Must be informational in nature</td>
<td>• Must be 3–5 minutes in length</td>
</tr>
<tr>
<td>• Script of report must be turned in with project (or before if performance will be live)</td>
<td>• Must follow standard newspaper format</td>
<td>• Script must be turned in before play is presented</td>
</tr>
<tr>
<td>• Must be either performed live or recorded beforehand based on teacher discretion</td>
<td>• Must include a picture with caption that supports article</td>
<td>• May be presented to an audience or recorded for future showing based on teacher discretion</td>
</tr>
<tr>
<td></td>
<td>• Must be at least three paragraphs in length</td>
<td>• Should have props or some form of costume(s)</td>
</tr>
<tr>
<td></td>
<td>• Must be neatly written or typed</td>
<td>• Can include more than one person</td>
</tr>
<tr>
<td>Poster</td>
<td>PowerPoint—Presentation</td>
<td>PowerPoint—Stand Alone</td>
</tr>
<tr>
<td>• Should be the size of a standard poster board</td>
<td>• Must include at least 10 informational slides and one title slide with student’s name</td>
<td>• Must include at least 10 informational slides and one title slide with student’s name</td>
</tr>
<tr>
<td>• Must include at least five pieces of important information</td>
<td>• Should include no more than two words per page</td>
<td>• Should include no more than 10 words per page</td>
</tr>
<tr>
<td>• Must have a title</td>
<td>• Slides must have color and no more than one graphic per page</td>
<td>• Slides must have color and no more than one graphic per page</td>
</tr>
<tr>
<td>• Must contain both words and pictures</td>
<td>• Animations are optional but should not distract from information being presented</td>
<td>• Animations are optional but should not distract from information being presented</td>
</tr>
<tr>
<td>• Name should be written on the back</td>
<td>• Presentation should be timed and flow with the speech being given</td>
<td>• Must provide bibliography or sources, if appropriate</td>
</tr>
<tr>
<td>• Must provide bibliography or sources, if appropriate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Cube</td>
<td>Puppet</td>
<td>Questionnaire</td>
</tr>
<tr>
<td>• All six sides of the cube must be filled with information as stated in the task</td>
<td>• Puppet should be handmade and must have a moveable mouth</td>
<td>• Must be neatly written or typed</td>
</tr>
<tr>
<td>• Must be neatly written or typed</td>
<td>• A list of supplies used to make the puppet must be turned in with the puppet</td>
<td>• Include at least 10 questions with possible answers</td>
</tr>
<tr>
<td>• Name must be printed neatly on the bottom of one of the sides</td>
<td>• $1 contract signed</td>
<td>• Questions must be helpful to gathering information on the topic being studied</td>
</tr>
<tr>
<td>• Should be submitted flat for grading</td>
<td>• If used in a puppet show, must also meet the criteria for a play</td>
<td>• If questionnaire is to be used, at least 15 people must provide answers</td>
</tr>
<tr>
<td>Quiz</td>
<td>Quiz Board</td>
<td>Recipe/Recipe Card</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>• Must be at least a half sheet of paper long&lt;br&gt;• Must be neatly written or typed&lt;br&gt;• Must cover the specific topic in detail&lt;br&gt;• Must include at least five questions including a short answer question&lt;br&gt;• Must have at least one graphic&lt;br&gt;• An answer key must be turned in with the quiz</td>
<td>• Must have at least five questions&lt;br&gt;• Must have at least five answers&lt;br&gt;• Should use a system with lights to facilitate self-checking</td>
<td>• Must be written neatly or typed on a piece of paper or an index card&lt;br&gt;• Must have a list of ingredients with measurement for each&lt;br&gt;• Must have numbered steps that explain how to make the recipe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scrapbook</th>
<th>Song/Rap</th>
<th>Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cover of scrapbook must have a meaningful title and student’s name&lt;br&gt;• Must have at least five themed pages&lt;br&gt;• Each page should have at least one meaningful picture&lt;br&gt;• All photos and pictures must have captions&lt;br&gt;• Must provide bibliography or sources, if appropriate</td>
<td>• Words must make sense&lt;br&gt;• Must be either performed live or recorded beforehand based on teacher discretion&lt;br&gt;• Written words must be turned in before performance or with taped song&lt;br&gt;• Should be at least 2 minutes in length</td>
<td>• Must be at least 2 minutes in length&lt;br&gt;• Should not be read from written paper&lt;br&gt;• Note cards can be used&lt;br&gt;• Written speech must be turned in before speech is presented&lt;br&gt;• Must be either performed live or recorded beforehand based on teacher discretion&lt;br&gt;• Voice must be clear, loud, and easy to understand</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Story</th>
<th>Three-Dimensional Timeline</th>
<th>Three Facts and a Fib</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Must have all of the elements of a well-written story (setting, characters, conflict, rising action, and resolution)&lt;br&gt;• Must be appropriate length to allow for story elements&lt;br&gt;• Must be neatly written or typed</td>
<td>• Must be no bigger than standard-size poster board&lt;br&gt;• Must be divided into equal time units&lt;br&gt;• Must contain at least 10 important dates and have at least two sentences explaining why each date is important&lt;br&gt;• Must have a meaningful, creative object securely attached beside each date to represent that date&lt;br&gt;• Must be able to explain how each object represents each date or event</td>
<td>• Must be written, typed, or created using PowerPoint&lt;br&gt;• Must include exactly four statements: three true statements (facts) and one false statement (fib)&lt;br&gt;• False statement should not be obvious&lt;br&gt;• Must include a brief paragraph that explains why the fib is false</td>
</tr>
<tr>
<td><strong>Trading Cards</strong></td>
<td><strong>Trophy</strong></td>
<td><strong>Venn Diagram</strong></td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Include at least 10 cards</td>
<td>Must be at least 6&quot; tall</td>
<td>Must be at least 8.5&quot; by 11&quot;</td>
</tr>
<tr>
<td>Each card must be at least 3&quot; by 5&quot;</td>
<td>Must have a base with the name of the person getting the trophy and the name of the award written neatly or typed on it</td>
<td>Shapes should be thematic and neatly drawn</td>
</tr>
<tr>
<td>Each card should have a colored picture</td>
<td>Top of trophy must be appropriate and represent the award</td>
<td>Must have a title for entire diagram and a title for each section</td>
</tr>
<tr>
<td>Include at least three facts on the subject of the card</td>
<td>Name should be written on the bottom of the award</td>
<td>Must have at least six items in each section of the diagram</td>
</tr>
<tr>
<td>Cards must have information on both sides</td>
<td>Must be an originally designed trophy (avoid reusing a trophy from home)</td>
<td>Name should be written on the back</td>
</tr>
<tr>
<td>All cards must be submitted in a carrying bag</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td><strong>WebQuest</strong></td>
<td><strong>Windowpane</strong></td>
<td></td>
</tr>
<tr>
<td>Use VHS, DVD, or Flash format</td>
<td>Must quest through at least five high-quality websites</td>
<td></td>
</tr>
<tr>
<td>Turn in a written plan or story board with project</td>
<td>Websites should be linked in the document</td>
<td></td>
</tr>
<tr>
<td>Students will need to arrange their own way to record the video or allow teacher at least 3 days notice to set up recording</td>
<td>Can be submitted in a Word or PowerPoint document</td>
<td></td>
</tr>
<tr>
<td>Covers important information about the project</td>
<td>Includes at least three questions for each website</td>
<td></td>
</tr>
<tr>
<td>Name should be written on the video label</td>
<td>Must address the topic</td>
<td></td>
</tr>
<tr>
<td><strong>Worksheet</strong></td>
<td><strong>You Be the Person Presentation</strong></td>
<td></td>
</tr>
<tr>
<td>Must be 8.5&quot; by 11&quot;</td>
<td>Take on the role of the person</td>
<td></td>
</tr>
<tr>
<td>Must be neatly written or typed</td>
<td>Cover at least five important facts about the life or achievements of the person</td>
<td></td>
</tr>
<tr>
<td>Must cover the specific topic or question in detail</td>
<td>Must be 2–4 minutes in length</td>
<td></td>
</tr>
<tr>
<td>Must be creative in design</td>
<td>Script must be turned in before information is presented</td>
<td></td>
</tr>
<tr>
<td>Must have at least one graphic</td>
<td>Should be presented to an audience with the ability to answer questions while in character</td>
<td></td>
</tr>
<tr>
<td>An answer key will be turned in with the worksheet</td>
<td>Must have props or some form of costume</td>
<td></td>
</tr>
</tbody>
</table>
Appendix H

Sample Test

Algebra II
Chapter 5 Test

Name: ______________________________ Date: ______________

1. Find the equation of the parabola that passes through the point (-5, 5) and has a vertex (2,-5). Write the equation in standard form. (5 pts.)

   Equation: ______________
   Axis of Symmetry: __________

2. Find the inverse of each function. Find the domain and the range of the inverse. Graph both equations on the same coordinate grid. (5 pts.)

   $Y = \frac{2}{3} x - 7$

   Inverse Equation: ______________
   Domain of the Inverse: ___________
   Range of the Inverse: ____________
3. \( Y = x^2 + 4 \)

Inverse Equation: _________________
Domain of the Inverse: _____________
Range of the Inverse: ______________

Solve each quadratic equation by factoring. (3 pts. each)
4. \( x^2 + 2x = 3 \) _________________

5. \( x^2 - 36 = 0 \) _________________

Solve by completing the square. Show your work. (3 pts. each)
6. \( x^2 + 10 = 4x - 2 \) _________________

7. \( x^2 - 4x - 6 = 0 \) _________________
Simplify each expression. (2 pts. each)

8. \((4+2i) - (3+5i) = \) ________________

9. \((6-i)(4+5i) = \) ________________

10. \(i^{10} = \) ________________

11. \(\text{abs}(-2 + i) = \) ________________

Solve each equation. (2 pts. each)

12. \(9x^2 + 1 = 0 \) ________________

13. \(4x^2 + 36 = 0 \) ________________

14. Write the quadratic equation (in standard form), if its solutions are:
   \(x = -1\), and \(x = 2\) (2 pts.)

   _____________________________
15. The height $h(t)$ in feet of a stone thrown in the air after $t$ seconds can be modeled by $h(t) = -16t^2 + 40t$. Write this equation in vertex form. What is the maximum height of the stone? (2 pts.)

16. While in orbit, a space scientist measures the pressure inside a container, as it is being heated and then cooled. She records the information and discovers the pressure $p$, in pounds per square inch, is related to the time $t$ in minutes after the experiment begins according to the equation:

$$p = -0.2t^2 + 1.6t.$$  

(a) Complete the square in the expression $-0.2t^2 + 1.6t$.
(b) Rewrite the equation for $p$ in vertex form.
(c) What is a reasonable domain for this function? Explain.
(d) When does the maximum pressure occur? What is the maximum pressure?
Appendix I

Code Manager of Primary Documents
Appendix J

Checklist

In your group, make sure to check the line near each question provided once it is completed.

_______ 1. Are you keeping track of the time?
_______ 2. Are you making sure every voice in the group is heard?
_______ 3. Are you checking in with each team member periodically?
_______ 4. How are you implementing the group processing of the work?
_______ 5. Are you respecting the contributions of others?
_______ 6. What is your individual responsibility in the group?
_______ 7. Are you asking for clarifications from all members of your team?
_______ 8. Did you build on the ideas of others?
_______ 9. Did you build on comments of other group members to enhance discussion?
_______ 10. Did you volunteer ideas in a constructive manner?
Appendix K

Direct Observation # 1

Laila - Classroom observations 2015-16
1-28-16
Algebra II

Goal:
- Develop highly differentiated unit in algebra II
- continue to develop a safe and nurturing classroom environment in the following:
  - 1. discuss attitude:
    - students were collaboratively working in their groups.
    - Teacher labeled the groups by color not number
    - Class was very organized. Students knew where to find all the material they might need during the lesson.
    - There a routine established by the teacher and high expectations that are transparent among all the constituents in class.
    - Student- to -student and student -to -teacher attitude was phenomenal. They all worked collaboratively and partners. Teacher was working with the students at the same table, making sure to rotate among the different groups as needed.
  - 2. motivation :
    a. Teacher - Very enthusiastic about her work. Students and observers can notice the passion the teacher has for math and for her students.
    B. Student - Students were engaged for the last 70 minutes. Working on their activity sheets and discussing their work in groups. Some were quiet but not for a long period of time.
    - study skills: the teacher discussed homework expectations, projects, and efficient ways of doing the work. Insisted on not copying answers from other classmates and focused on the process of thinking about a problem and using logic and estimation when necessary as a guide for a problem at hand.
    - time management: working efficiently in class and using free periods and lunch time for help if needed. The rhythm of the class and the efficiency were evident. The teacher had a good control over time management and getting the learning objectives covered for the day.
    - to stress learning and analyzing over memorizing and solving.

<table>
<thead>
<tr>
<th>Time</th>
<th>Teacher</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:45 - 1:45</td>
<td>moving from group to group - asking and answering questions</td>
<td>students divided into 4 groups by readiness level</td>
</tr>
</tbody>
</table>
| Laila’s questions to the lower tier groups are specific and aimed at helping students move through the process of working a problem - asking students to “explain your thinking process to me,” for example | all working on quadratic v linear equations, but at varying levels of sophistication. Groups had varying levels of functionality as groups.
Aubrey drove her group, keeping everyone in the same place, and checking answers.
Toral led her group, Alex asked some questions; Kimmy trying to follow along, but not adding much.
Rory’s group worked efficiently and collaboratively - number of highly social and naturally collaborative students in that group.
Emily’s group was divided - the two sides of the table didn’t talk to each other much at all. |
| --- | --- |

Questions after lesson: how to encourage groups to work together?
- maybe have students share one activity sheet rather than everyone having an individual copy
- have students debrief collaborative process at the end of class - have them use a specific thinking or collaborative process rubric as a guideline
During Mrs. Ariss' Algebra 2 class, I observed differentiated instruction through tiered groups, in which students were organized by their performance on a pre-assessment. Her class was divided into four tiers, and students were given specific group work that aligned with their current knowledge of the material. Within each tiered group, students were asked to complete their choice of three tasks from a Tic-Tac-Toe handout of nine total tasks; they were required to complete three tasks in order to receive a Tic-Tac-Toe (i.e., three in a row).

During her class, Mrs. Ariss would spend time with each group as needed; however, it appeared like the groups that most often needed her support were the first two tiers, as they were the least proficient with the material. More specifically, Mrs. Ariss would work with students in these two tiers by chunking the material and explaining the concepts in more detail. She would also help these students make the connections they needed to retain the information as they completed their chosen tasks, as her goal was to help them reach the same outcome as their peers, but at a more appropriate level of difficulty.

It was impressive to observe Mrs. Ariss' interactions with her students at each of the four tiers, as she successfully changed her language to align with the level of support they needed. Most importantly, it appeared that students in the lower tiers did not feel behind in the material from those in tiers 3 and 4, as all students were completing the same type of work and were set up to feel successful on their particular tasks. Also important, students in tiers 3 and 4 received the enrichment they needed in order to feel engaged and challenged in her class.

It was also impressive to observe the students' interactions with each other, as Mrs. Ariss' design encouraged them to interact and remain on task. I observed students with a history of not participating in class becoming engaged with their peers and I observed students who struggle to stay on-task remain focused and eager to work through the tasks. As a learning specialist, Mrs. Ariss' method of differentiated instruction is highly recommended for meeting students at different readiness levels, especially those in need of developing mathematics self-efficacy.