THE EFFECTIVENESS OF DIFFERENTIATED INSTRUCTION IN THE ELEMENTARY MATHEMATICS CLASSROOM

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE DOCTOR OF EDUCATION

BY

BRIAN E. SCOTT

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BALL STATE UNIVERSITY

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ABSTRACT

DISSERATION/THESIS/RESEARCH PAPER/CREATIVE PROJECT: The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom

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This study was conducted to determine if differentiated instruction improved student growth. The overall effectiveness was studied as well as that of gender and the aptitude of average and above average students. The study was that of a quasi-experimental design using student subjects in the classrooms of three second-grade teachers. The school in the study was located in an affluent suburb outside of a major city in the Midwest. This quantitative study concluded that differentiated instruction did not have an overall effectiveness at a significant level. Students with a higher academic ability benefited significantly with opportunity to be challenged at a higher level while students of average ability did not. There was no significant difference between the achievement of males and females.

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CHAPTER I: INTRODUCTION

Area of Concern

Differentiated instruction has been a "buzz phrase" in American education for many years. Much of what has been written in support of the practice was created in the 1990's. Bearne (1996) defines differentiation as an approach to teaching in which teachers proactively modify curricula, teaching methods, resources, learning activities, and student products to address the diverse needs of individual students and small groups of students to maximize the learning opportunity for each student in a classroom. Differentiated instruction is responsive teaching. Differentiation is a modification of teaching and learning routines and can address a broad range of learners' readiness levels, interests, and modes of learning (Tomlinson, 2001). It stems from a teacher's solid and growing understanding of how teaching and learning occur, and it responds to varied learners' needs for more structure or independence, more practice or greater challenge, and more active or less active approaches to learning.

Supporting the practice are four guiding principles that relate to differentiating classroom practices: (a) a focus on essential ideas and skills in each content area, (b) responsiveness to individual student differences, (c) integration of assessment and instruction, and (d) an ongoing adjustment of content, process, and products to meet individual students' levels of prior knowledge, critical thinking, and expression styles (Tieso, 2003; Tomlinson, 1999). Lending further credence to the approach are seven basic beliefs (Tomlinson, 2000b): (a) same-age students can differ greatly in their life

circumstances, past experiences, and readiness to learn; (b) these differences have a significant impact on the content and pace of instruction; (c) student learning is improved when they receive support from the teacher that challenges them to work slightly above their comfort level; (d) student learning is enhanced when what they are learning in school is connected to real-life experiences; (e) student learning is also strengthened by authentic learning opportunities; (f) student learning is boosted when they feel they are respected and valued within the context of the school and community; and (g) the overarching goal of schooling is to recognize and promote the abilities of each student.

Lawrence-Brown (2004) reported that differentiated instruction has a great importance for students who struggle in the mastery the grade level curriculum. Two goals are achieved as a result of differentiated instruction. First, and foremost, a high level of achieving the grade level standards for all students is paramount. It is important for teachers to scaffold the instruction as necessary for struggling learners. The second goal is to make curricular adaptations for those students who need it.

Teachers who differentiate are quite aware of the scope and sequence of curriculum prescribed by their state, district, and school. They are also aware of the students in their classrooms who begin each school year spread out along a continuum of understanding and skill. The teacher's goal is to maximize the capacity of each learner by teaching in ways that help all learners bridge gaps in understanding and skill and help each learner grow as much as quickly as he or she can (Tomlinson and Eidson, 2003). Tomlinson (2001) writes that a differentiated classroom provides different paths for

acquiring the content, causes the teacher to support students in processing or the making sense of ideas, and helps students create products so they can learn effectively.

A teacher can differentiate instruction in many ways in various subjects. Instruction can be differentiated based on a student's readiness, learning profile, or interest by varying the content, process, or product (Tomlinson, 2001). The main strategies utilized are compacting, independent projects, interest centers or interest groups, tiered assignments, flexible grouping, learning centers, varying questions, mentorships, anchoring activities, and learning contracts.

Because of this active interest in differentiated instruction for all learners, many quick-fix ideas have been proposed. There are many resources, mainly in the form of books, offering teachers a large number of strategies, but these often lack the philosophy of differentiated instruction. Professional development companies create one-day workshops as a means of giving the participant an instant "everything-you-need-to-know" training on differentiated instruction. District and building leaders hire consultants to train faculties in a one-time session on differentiated instruction. Because differentiated instruction is a complex concept, teachers need to remember that professional development cannot provide a "one-size-fits-all" approach to teaching just one lesson plan and will not meet the needs of all of the students in a class. Few teachers automatically know how to lead a classroom that responds to the overwhelming reality of students' varying needs. It takes time. As a teacher becomes more comfortable and competent with differentiation, his/her role changes to more of a director of the classroom

environment, a coach on the side guiding students, and an improviser adjusting the required instruction at the moment based upon ongoing assessment.

One of the strategies of differentiated instruction is flexible grouping, which may take on different forms in the education literature. Flexible grouping is one type of ability grouping, described in a research study conducted by Slavin (1986) as group-paced mastery learning. Referencing Bloom (1976), he cites group-paced learning as a form of flexible within-class ability grouping, in that students are grouped after each lesson into "masters" and "nonmasters" groups on the basis of a formative test. Nonmasters received corrective instruction while masters did enrichment activities.

While grouping may be thought to be a negative practice in education, Kulik and Kulik (1982) reported the results of fifteen studies on student self-concept. In seven studies, self-concept was higher for students in grouped classrooms; in six studies, self-concept was higher for students from ungrouped classrooms; and in two studies, self-esteem was equal for the two groups. The average effect size (ES) was .01, a trivial value (Kulik and Kulik, 1982). While these studies were based more on ability grouping, the results are worthy of consideration as a research finding. This is due to flexible grouping having some similarity to ability grouping. The major difference is that ability grouping is often perceived as being static, whereas flexible grouping changes based on the mastery of skills by the student. In a later meta-analysis in 1992, Kulik concluded that evidence on the noncognitive outcomes of grouping is not as clear. Noncognitive instructional outcomes are not often studied by educational researchers, and only tentative conclusions can be drawn despite their importance. Grouping has been thought

to have only small effects on student self-esteem. It is not believed to lead talented students to become self-satisfied or smug, nor does it cause a precipitous drop in self-esteem of lower students (Kulik, 1992).

A qualitative study by Carol Tieso (2001) indicated that students in a differentiated classroom setting can become more engaged, motivated, and excited about learning if the curriculum is authentic and meaningful and if appropriate learning goals are provided. Because students received the necessary modifications to meet their specific learning needs, either more challenging or layered in order to achieve mastery, Tieso also found that students did not lose their sense of self-concept or self-efficacy.

Assessment is a key component of flexible grouping. It can take varied forms, but it should occur before, during, and at the conclusion of a unit of study. Witham and Linehan (1995) reported through survey findings of 109 teachers that slightly more than half of the teachers at that time felt that pretests were worth the effort and should be used more often. Teachers with master's degree endorsements had a more positive attitude about pretests than those who did not. This leads to the conclusion that slightly less than half of the those who responded felt they were too time consuming, unnecessary, not applicable to certain subjects, and not practical. The authors further reported that 30 percent of the respondents had never pretested in subjects such as spelling or reading, seventeen percent did not pretest in math, and 36 percent did not pretest in grammar or writing. Approximately fifty percent did not pretest in social studies or science.

To avoid making erroneous decisions regarding individual instructional needs, the teacher needs to be aware that not all students are the same. As a result of a synthesis of

the literature, Tonya Moon (2005) states, "This assumption leads to erroneous decisions that may (a) prevent students from mastering the intended learning objectives, (b) disengage students from the process of learning because the materials are not accessible to them, (c) result in negative student behaviors or attitudes, or (d) propagate the achievement gap" (p. 229).

As teachers are faced with high levels of accountability, often having to prove that learning has taken place, pretesting becomes a critical baseline. The intent of assessment of instruction is to help the teacher make decisions about the best approach to instruction for students. When a teacher assesses students' strengths and weaknesses, the teacher uses that information to make decisions about where instruction should begin, or on which particular learning goals to focus (Moon, 2005).

Differentiation occurs concurrently with assessment and grouping. The way assessment is used to create groupings is unlike using it to create stagnant ability groups. While assessment helps to determine which students need more challenge, which ones are performing at grade level, and which ones need scaffolding to meet the expectations, the teacher must make a decision as to how to make the lesson engaging and focused. This would consider such approaches such as brain compatibility, learning styles, and cooperative learning strategies.

Statement of the Problem

Differentiated instruction is viewed in schools as a positive approach to meeting the needs of the wide-range of abilities in the classroom, but most of the research supporting it is of a qualitative nature, especially in a heterogeneously mixed classroom.

Much has been written about its importance in gifted and talented education as well as special education.

While the strategies of differentiated instruction have been used in classrooms for many years, results of the practice have been limited in quantitative studies. Much has also been written about how complex of a concept differentiation is. Educators should be cautious to not make too much of a drastic change in implementing the practice to the classroom. In view of differentiation being grounded in assessment, often of a numerical nature, it appears to be unusual that more quantitative studies have not been done. More schools, administrators, and teachers desire to embrace the practice often not having a full understanding of the time commitment it takes to fully implement it. Teachers and administrators need more research to support the effectiveness of differentiated instruction. For this study, mathematics is being chosen as the subject. Math is more of a skills-based subject and has the flexibility to use many of the differentiated strategies such as flexible grouping, anchoring activities, and compacting.

The Third International Mathematics and Science Study (TIMSS) in 1995 reported that American fourth graders score better than the average of their counterparts in 26 countries. Seven countries were significantly higher than the U.S. and twelve were significantly lower. Six countries were performing about the same as the United States. In the 2007 study, fourth graders were better than 23 of the 35 countries and lower than the top 8. These top performing countries were located in Asia and Europe. The 2007 average score was better than in 1995 by 11 points. While the average score improved, the United States is still not at the top over the twelve-year period. This demonstrates the

importance of investigating whether differentiating instruction can impact the performance of American children when compared to their same-aged peers on a global level. The report also indicated that the achievement gap in mathematics between males and females is still wide with males achieving at higher levels.

Several qualitative studies have been conducted and indicate positive results (Tomlinson 1995; George, 2005), but there have been few of a quantitative nature. *The Differentiated School: Making Revolutionary Changes and Learning* by Tomlinson, C., Brimijoin, K., & Narvaez, L (2008) tells of multi-year studies in an elementary school and a high school indicating positive and sustained achievement gains for students in all segments of the achievement spectrum and in a range of subject areas as a result of differentiated instruction. In the high school, the student dropout rate has also fallen sharply, and student participation in Advanced Placement courses has risen by almost half, with AP exam scores holding steady or rising despite the increased enrollment. In both sites, a school-wide emphasis on differentiation has continued for at least seven years, and achievement gains have continued over that time span. This study seeks to answer the question of the effectiveness of differentiated instruction in a quantitative research design. Very few studies of this approach have been done quantitatively, and the field of education could potentially benefit from the findings. In addition, the study attempts to see if an increase in math achievement is accomplished by implementing differentiated instructional strategies.

Research Questions

This study poses one main question followed by two other questions disaggregated from this main inquiry. The additional questions are being included for different reasons. The first of the related questions will explore an area sparsely found in the literature review of this particular study regarding gender and differentiated instruction. The second will look for some consistency from the study by Tieso finding that students with a greater aptitude benefited greatly from differentiated instruction. The three questions are:

Does differentiated instruction impact the growth of student learning in the subject of math?

Does differentiated instruction impact the growth of student learning of a particular gender in the subject of math?

Does differentiated instruction impact the growth of student learning of a particular aptitude in the subject of math?

The hypothesis in this study is that differentiated instruction does improve academic achievement. This study will look at the results, not only in terms of the second grade students as a whole, but also in terms of gender and aptitude. Quantitatively this can be measured by comparing results of instruction that does not differentiate with instruction that does based on growth data using pre- and posttests. There are three null hypotheses as follows.

1. There will be no significant change in student mathematics achievement growth using differentiated instructional techniques.

2. There will be no significant change in student mathematics achievement growth using differentiated instructional techniques between males and females.
3. There will be no significant change in student mathematics achievement growth using differentiated instructional techniques among ability levels.

Definition of Important Terms

Anchoring activity Students automatically move when they complete an assigned task during a daily lesson or unit of study. It is important in maintaining a productive work environment and ensures wise use of a student's time (Tomlinson, 2001). Examples of anchoring activities are reading, journal writing, portfolio management, and practicing skills through manipulatives or sorting activities. Anchoring activities may take the form of learning centers. It is possible that some students will participate in these activities more than others.

Aptitude This is the capacity for learning a student demonstrates. It can be considered synonymous with ability. Some in the field of education would erroneously consider this to be equivalent to a student's intelligence quotient (IQ). Aptitude is measured using an assessment tool designed to measure a student's ability often in a classroom setting to a group of students at the same time. The Otis-Lennon School Abilities Test (OLSAT) by Pearson Assessment and the Cognitive Abilities Test (CogAT) published by Riverside Publishing are examples. An IQ is best measured using a tool given by a trained psychologist in a one-on-one situation.

Learning Centers Learning centers can be "stations" or collections of materials learners use to explore topics or practice skills. Teachers can adjust learning center tasks to readiness levels or learning styles (Tomlinson, 2001).

Compacting This is a 3-step process that (1) assesses what a student knows about material to be studied and what the student still needs to master, (2) plans for learning what is not known and excuses the student from what is known, and (3) plans for freed-up time to be spent in enriched or accelerated study (Tomlinson, 2001).

Tiered assignments In a heterogeneous classroom, a teacher uses varied levels of activities to ensure that students explore ideas at a level that builds on their prior knowledge and prompts continued growth. Student groups use varied approaches to explore essential ideas (Tomlinson, 2001). At times these may look similar to varying questions.

Varying questions In class discussions and on tests, teachers vary the sorts of questions posed to learners based on their readiness, interests, and learning styles (Tomlinson, 2001). These types of questions may also vary on tiered assignments.

Flexible grouping Students are part of many different groups—and also work alone—based on the match of the task to student readiness for instruction, interest, or learning style. Teachers may create skills-based groups that are heterogeneous or homogeneous in readiness level. Sometimes students select work groups, and sometimes teachers select them. Sometimes student group assignments are purposeful and sometimes random (Tomlinson, 2001).

Contracts Contracts take a number of forms that begin with an agreement between student and teacher. The teacher grants certain freedoms and choices about how a student will complete tasks, and the student agrees to use the freedoms appropriately in designing and completing work according to specifications (Tomlinson, 2001).

Pretesting Pretesting is a technique used to find out what a student knows and does not know prior to formal instruction. This form of assessment is often the driving force in determining how, why, and what type of differentiated instruction will take place.

Significance of the Problem

While there is a great amount of support for the strategies related to differentiated instruction, there have not been a large number of research studies indicating that differentiated instruction helps students grow in their academic endeavors. Kronberg, York-Barr, Arnold, Gombos, Truex, Vallejo, and Stevenson (1997) report that classrooms are becoming increasingly heterogeneous, and teachers frequently work amidst complex and sometimes unpredictable situations. Jenkins, Jewell, Leicester, O'Connor, Jenkins, & Troutner (1990), indicated that heterogeneity is represented by students with diverse cultural, racial, religious, and linguistic backgrounds; family structures; socioeconomic status; and ability levels. Our public schools have a vast majority of teachers who are currently or soon will be expected to teach students with markedly diverse backgrounds and abilities. It has been estimated that the range of instructional levels among students (those not receiving any special services) in many

general education classrooms is an average of 5.4 grade equivalents (Jenkins, Jewell, Leicester, O'Connor, Jenkins, and Trouter, 1990).

Students with diverse backgrounds and abilities pose new and different challenges as teachers seek to meaningfully include and effectively educate all students (Kronberg, York-Barr, Arnold, Gombos, Truex, Vallejo, & Stevenson, 1997). Most certainly, as diversity among students increases so must the differentiation of teaching and learning (Kronberg, York-Barr, Arnold, Gombos, Truex, Vallejo, & Stevenson, 1997). The problem in classrooms for academically diverse student populations is likely systemic. Literature has proven in many forms that the patterns of inattention to student variance are evident and related specifically to numerous learner exceptionalities, such as giftedness, special education, second language acquisition, multicultural learners, and students from low economic backgrounds. The problems lie in beliefs and practices related to teaching, learning, and the nature of people as learners, the best ways to teach, and how students should learn. It is critical that educators understand and address the systemic issues. Contemporary schools with their diverse populations must consider the learning needs to be shaped by readiness, interest, or learning profile. Teachers have to address these varied academic needs and investigate and address the persistent and long-held teacher beliefs. While this study does not address diversity beyond gender and aptitude, the impact of this awareness and the curriculum and instruction teachers plan and deliver to diverse learners is critical. Such an approach and consideration of the big issues may well be a precursor to addressing effectively the particular learning needs of

specific learners and populations of learners (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover, and Reynolds, 2003, p. 125).

A substantial amount of the research regarding differentiated instruction is at a superficial level. As Tomlinson et al explain, the responsive classroom to meet academically diverse needs is a new concept. Knowing how to create an atmosphere of this responsiveness is the basis that might ultimately support such classrooms. For example, we do not know the particular range of students for whom differentiated, heterogeneous classrooms might be effective (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover, and Reynolds, 2003). We do not know which of a variety of potential models of teaching and learning might best serve the learning needs of students who differ as learners. Quantitatively we know little regarding the relative impact of differentiated instruction based on learner readiness needs versus interests, versus learning profiles—nor whether it is important to address all of those elements simultaneously. Likewise, we need to investigate the impact of such classroom elements as learning environment and the effect on achievement of diverse populations (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover, and Reynolds, 2003).

In a paper presented before the Association for Supervision and Curriculum Development, Ronis (1999) shared that The National Council of Teachers of Mathematics (NCTM) recommends through its Principles and Standards that instruction needs to be more than mastery of facts and routine skills but should result in all students gaining understanding and the ability to apply mathematical concepts in new situations.

Ronis goes on to describe six pillars of performance tasks that she states are brain-compatible, another way to differentiate instruction. These elements are to establish clear goals using the content standards, employ authentic tasks, emphasize critical levels and performance standards, provide models of excellence, teach strategies explicitly, and provide ongoing assessments with timely feedback. The sixth pillar aligns well with differentiated instruction. Assessment is a critical component as indicated by it driving the planning, guiding, and evaluating of instruction. She contends that teachers must move away from teach, test/grade, and move on, to adopt the practice of teach, assess, adjust, and assess.

Small group instruction, the opportunity to have students focusing on skills of the greatest need, extension for students who have mastery of the core curriculum of skills, and the provision of individualized instruction make good sense. A teacher can differentiate instruction in many ways in various subjects. Instruction can be differentiated based on a student's readiness, learning profile, or interest by varying the content, process, or product (Tomlinson, 2001a). The main strategies utilized are compacting, independent products, interest centers or interest groups, tiered assignments, flexible grouping, learning centers, varying questions, mentorships, anchoring activities, and contracts. The strategies of flexible grouping, anchoring activities, and tiered assignments will be utilized. In this study, it should be noted that a teacher may start out focusing on one or two strategies and will end up incorporating others.

Basic Assumptions

One of the basic assumptions in this study would be that teachers administer any and all assessments with fidelity. Teachers will receive two full days of training prior to implementation of the experiment. The training will include an overview of differentiated teaching strategies including video demonstrations of teachers using these techniques. Teachers in the study will receive training to better use differentiated instruction through improved understanding of assessment data, classroom management, and creating multiple pathways for learning. Because the teachers involved are not new to the profession, one would believe that long-standing instructional strategies these teachers have developed in the past could potentially be used again. Each teacher will be observed for two 30-minute periods prior to the training and for two 30-minute periods after the training during the implementation phase. These observations serve as a baseline of typical instructional practices before the training and to ensure fidelity of the application of training sessions during the implementation of deliberate differentiated instruction.

Basic Limitations

Three second grade teachers with classroom sizes of approximately 26 students each will participate in the study. Two of these are special education inclusion classrooms with four students each identified with some sort of minor learning disability such as attention deficit hyperactivity disorder or difficulty with reading and language development. All three classes will be in the same school, which could potentially help with the collaboration and fidelity of the instructional strategies employed.

While a control and experimental design would have been preferred, the quasi-experimental design was chosen due to the teachers' willingness to participate. The smaller number of participants was also a factor to validate the results more accurately. The study might have a different result with a larger sample of teacher participants and classrooms of students.

The subject school is a public school in an affluent suburb northeast of Indianapolis, Indiana. It could be challenging to generalize the results, especially if they are positive, to other schools of more diverse demographics due to the perceived notion that differentiated instruction will only work in this certain group. For this study, the convenient population will limit this study to gender and aptitude. The small sample of special education students, the lack of racial diversity, and few students of lower socio-economic status in this particular school would not permit a valid or deep analysis of these subgroups.

Summary

Because there is little quantitative research on differentiated instruction, this study could add some very important information to the approach and its effectiveness. There is little doubt as to the necessity to address so many avenues for learning due to the wide range of students. As the review of the literature will imply, differentiated instruction has been provided for some students for quite some time. Due to its wide acceptance in the fields of gifted education and special education, two seemingly polar opposites, it is critical that more research be done in heterogeneous classrooms.

CHAPTER II: REVIEW OF THE LITERATURE

Historical Background

Basing her ideas on the work of Vygotsky (1986); Csikszentmihalyi (1997); and Sternberg, Torff, and Grigorenko (1998), Tomlinson writes:

> There is ample evidence that students are more successful in school and find it more satisfying if they are taught in ways that are responsive to their readiness levels (e.g. Vygotsky, 1986), interests (e.g., Csikszentmihalyi, 1997), and learning profiles (e.g., Sternberg, Torrf, & Grigorenko). Another reason for differentiating instruction relates to teacher professionalism. Expert teachers are attentive to students' varied learning needs (Danielson, 1996); to differentiate instruction, then, is to become a more competent, creative, and professional educator. (2000a, p. 3)

It is common to find references in articles related to differentiated instruction tying the approach to the work of cognitive psychologist, Jerome Bruner. Bruner in the 1960's and 70's believed that a student could learn just about anything if the structure of the lesson was designed appropriately. According to Bell (2004):

> In *The Process of Education*, Bruner offers the foundational conjecture that "it is the underlying premise of laboratory exercises that doing something helps one understand it." Derived from the individualistic Piagetian view of the active construction of knowledge through inquiry that was emerging at the time—which fueled the central arguments of *Process*—it helped launch the subsequent

> ‘learning through discovery’ movement and ultimately the recognition that discovery was being taken as an end rather than a means for knowledge construction. (p. 8)

As Bruner (1985) indicates, there is no one way or one kind of learning. Conflicting thoughts on the best approaches to teaching and how students learn best are at odds with the instructional practices of a preceding generation. It is not appropriate to think that one learning theory would eventuate into one winning over the others. Any learner has a host of learning strategies to command. Perhaps the best choice is not a choice of one, but an appreciation of the variety possible. The appreciation of that variety is what makes the practice of education something more than a scripted exercise in cultural rigidity and sameness.

Bruner, in collaboration with Kenney, made a connection to the “doing” students need to experience in their learning with mathematics. The study was based on Piaget’s stages of learning development and the concern for children who need concrete examples and are not ready for formal operations. The study included four eight-year-olds, two boys and two girls. Each had an IQ between 120 and 130. They were from professional, middle-class families, and attended third grade in a private school. A well-respected mathematics researcher and a psychology assistant provided instruction with a focus on the human thought processes. The instruction emphasized concrete construction. Bruner and Kenney found that mathematics should be viewed as a microcosm of intellectual development. Engagement is a critical component for building the foundation of

understanding. Once the learner has a firm grasp on the concrete, the abstract and symbolic can be achieved.

Slavin has conducted and written about grouping and cooperative learning. In the 1980's he wrote about the effects of ability grouping on students, both negative and positive. Slavin (1987) found that above average students benefitted from being a part of a static group of similar achievers. In a synthesis of research of ability grouping he defined one type of ability grouping, and he found the following regarding the regrouping of students for reading and mathematics instruction:

> Often, students are assigned to heterogeneous homeroom classes for part or most of the day, but are "regrouped" according to achievement level for one or more subjects. In the elementary grades, regrouping is often done for reading (and occasionally mathematics), where all students at a particular grade level have reading scheduled at the same time and are re-sorted from their heterogeneous homerooms into classes that are relatively homogeneous in reading level (p.295).

Slavin recounts the research findings of Provus (1960) regarding regrouping in mathematics. The results were positive countered by a smaller study where the results were not quite as positive. Students in 11 classes in a suburb of Chicago were regrouped from their heterogeneous homerooms into relatively homogeneous mathematics classes at the same grade level. The original study conducted by Provus during the 1957-58 school year garnered the following results: 1) children were familiar with more arithmetic concepts grouped as to ability than children not so grouped; 2) children who were grouped were just as proficient as those children who were not grouped, and some

children grouped as to ability were more familiar with the fundamentals normally taught at their grade level than children who were not grouped as to ability; 3) a comparison of three different levels of students, indicated that bright children, benefitted most, average children may have profited slightly, and the slow learners may have profited no more from ability grouping than they would have from a heterogeneous class; 4) children in the upper elementary grades achieved at a substantially higher level than the children in these grades during the year before the experiment; 5) student interest in the subject matter was noticed in the control or experimental groups and assumed to be associated to ability grouping; 6) teachers largely supported the program, and most expressed a desire to teach homogeneous classes the following year. Based on these findings, ability grouping for arithmetic instruction was extended to the third through eighth grades in the Homewood schools for the 1958-59 academic year (Provus, 1960).

Slavin (1987) counterbalances the Provus findings with research conducted in 1963 by Davis and Tracy in the now discontinued National Teacher of Mathematics Council's journal, *Arithmetic Teacher*, regarding the harm of ability grouping. Slavin writes, "In contrast, Davis and Tracy (1963) found that regrouping for mathematics was detrimental to the achievement of students in a rural North Carolina town. However, this study compared only two schools, and there were substantial achievement differences at pretest" (p. 310). Slavin goes on to point out that there was no attempt made to include differentiated materials for students. All classes used the same grade level textbook.

Tomlinson, in a 1995 edition of *Gifted Child Quarterly*, found several challenges regarding a change to a differentiated instructional approach. The school in the study

was located in an affluent community in the Midwest. The school experienced high levels of achievement as indicated by the statewide testing instrument. Tomlinson found initial teacher opposition toward modifying instruction to suit varied needs of the learners. In addition, the initiative to implement a more proactive approach to instruction came from the administrative level, thus making an impact on the teacher's sense of self-efficacy. Other obstacles included teachers' perceptions that differentiated instruction would be a passing fad, something experienced by other professional development initiatives. There were also concerns over time allocated to prepare for differentiated lesson, unease over student assessments and preparation for testing, disquiet regarding classroom management and perceived teacher insecurity over a change in their role (Tomlinson, 1995). Teachers who adopted the use of differentiated techniques demonstrated that attitude for the need for the changes was more prevalent than age or years of experience. Teachers who experienced early successes with differentiation were more likely to persist (Tomlinson, 1995). Tomlinson concluded that schools need to do more than explore at a superficial level when it comes to addressing academic diversity. Teachers at the elementary school level often have great flexibility but might lack some in-depth subject area knowledge often due to having elementary classroom background, and secondary teachers have deep subject area capability but lack a variety of instructional approaches. Teachers were quite concerned that classrooms would become out of control. By allowing and encouraging collaboration, Tomlinson found that the classroom management issues expressed by those who more resistant had the potential to subside.

Tomlinson, Moon, and Callahan (1995) conducted an investigation by surveying administrators and teachers about instructional practice in middle school populations. The findings were that few teachers take into account student cultural differences, learning profile, or interests when creating lesson plans. To address diversity, instructional design was prevalently teaching teams. Building principals and teachers also indicated that middle school students were more socially focused than academic, required basic skill instruction, were concrete thinkers, were extrinsically motivated, and indicated that varying the curriculum and offering students choice of tasks the least important approach with this age group of students. Teachers also indicated that cooperative learning strategies best addressed the varying academic needs of the students in the classroom including those with lower academic as well as those students who would be considered gifted. The authors suggest that different models of professional development be reviewed to support teachers better for the implementation of differentiated strategies.

People with strong ties to gifted and talented education paved the way for highly able students to experience a differentiated approach to learning. Experts in the field supported a separate curriculum and approach for teaching high ability students. As time progressed, teachers saw other teaching strategies such as learning styles, Multiple Intelligences, and brain-compatible techniques, as paths to differentiating instruction. With the implementation of No Child Left Behind (NCLB) in 2001, schools and districts are held accountable through benchmark assessment results. Educators began to look at differentiated instruction as an instructional practice in which all students could achieve.

Rather than emphasizing the same teaching strategy that may have been appropriate for some, schools began to discover that the same strategy may not be effective for the most at-risk students. Even in the presence of high-quality curriculum and instruction, we will fall woefully short of the goal of helping each learner build a good life through the power of education unless we build bridges between the learner and learning (Tomlinson, 2001).

Theory Relevant to Research Question

Multiple theories can be related to differentiated instruction. These are not limited to but include Howard Gardner's Multiple Intelligence, brain-compatible learning, learning styles, and cooperative learning. Two dominant theories are Lev Vygotsky's theory of zone of proximal development (ZPD) and Robert Sternberg's three cognitive styles of learning.

Vygotsky was very concerned with the role of socialization in development. (Parker, 1979) In an explanation of the ZPD, Vygostsky wrote in 1978:

> Learning and development are interrelated from the child's very first day of life. A well known and empirically established fact is that learning should be matched in some manner with the child's developmental level (Vygotsky, p. 82).

A child's ZPD is that point in a learning experience that is slightly more challenging than what he or she can do alone. By students working within their zone, they are not interacting with work that is too easy or too difficult for them. The learning is meaningful because it appropriately meets the child's readiness level (Hall, 2002). Vygotsky claims the ZPD furnishes psychologists and educators with a tool through which the internal course of development can be understood (Vygotsky, 1978). He

continues to say that an essential feature of learning is that it creates the zone of proximal development. Learning stimulates various internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes become automatic, they become part of the child's independent developmental achievement. It is important to remember the notion that developmental processes do not coincide with learning processes. Instead, the developmental process falls behind the learning process; this sequence then results in zones of proximal development (Vygotsky, 1978).

Sternberg, along with research associate, Elena Grigorenko, looked at three major thinking styles. These are analytical, creative, and practical. In two studies, one conducted in 1995 and one in 1997, thinking styles were shown to impact how much a student learned. The 1995 study found that students were more positively evaluated by and received better grades from teachers who matched their styles than those who did not (Sternberg and Grigorenko, 1997). In another study conducted in 1997 of 199 high school students at a Yale University Summer Psychology Program, Sternberg and Grigorenko found consistent positive relations between preferred style and performance. When these abilities were used to predict school achievement, and then styles were added in through a hierarchical regression, styles made a significant incremental contribution to the prediction equation (Sternberg and Grigorenko, 1997).

Current Literature

The current research includes information published after 2001. Several themes were clear in the review of the literature. These were references to the previous theories

and research of a central group of experts, effect on a diverse population of students, and chief instructional strategies and arrangements. Other themes worth noting are the need for teacher training to bring change in classroom instruction and managing the classroom environment.

Many references in the literature include easily found research studies conducted by Joe Renzulli, Sally Reis, and Robert Slavin. Many of these go back as far as the early 1970's. Other reviews of the research cite Carol Tomlinson and Lev Vygotsky's theory of zone of proximal development as well as the aforementioned researchers.

Renzulli created the Schoolwide Enrichment Model (SEM) as a means of meeting the varied academic needs of students. The SEM is an organizational format that gives both enrichment and accelerated options through a continuum of high ability and integration. It allows for the highest potential growth for students and enables them to escalate their experience through options that might be available through other service delivery components. This can be in the form of general enrichment, highly individualized curriculum modifications for advanced learners, and first-hand investigative opportunities. The model also includes a broad array of specific grouping arrangements based on commonalities in abilities, interests, learning styles, and preferences for various modes of expression (Renzulli and Reis, 2002). Acceleration options include grade skipping, enrollment in college classes, and numerous supplementary program options that provide opportunities for talent development in specialized areas, such as Math League, Invention Convention, and National History Day Competition. Other components of the model include performance-based assessment of

student strengths, individual and group counseling, and various special placement options (within and outside the school) based on high degrees of proficiency and potential (Renzulli and Reis, 2002).

Tomlinson would be considered to be the most contemporary authority on differentiated instruction. She has written several books, has authored or co-authored many articles in educational journals, and is a featured speaker at education conferences. Others have published books using her ideas and applying the concepts into practical classrooms practices and strategies.

In her master's research project, Melinda Good found that most of the literature regarding differentiated instruction has been produced by Carol Ann Tomlinson.

> Although her experience and expertise are undeniable, the fact remains that this single viewpoint is the basis of much of the available differentiation literature. Clearly, the field would be expanded by the input of additional researchers (Good, 2006, p. 31).

As noted in Rock, Gregg, Ellis, and Gable (2008), Stamps (2004), Hall (2002), and Tieso (2005), experimental research studies on differentiated instruction are scarce. Although it seems logical to assume that greater scholastic gains would be made by students by teachers creating learning experiences tailored to their needs, controlled studies have not been performed to verify this idea. Particularly in this era of emphasis on quantifiable, verifiable data, having results that demonstrate the effectiveness of differentiation would likely increase its widespread acceptance as an educational strategy (Good, 2006).

Baumgartner, Lipowski, and Rush (2003) in their dissertation researched differentiated approaches that included flexible grouping in reading, student choice of various tasks, increased self-selected reading time, and access to various reading materials. The researchers found improvements in students' instructional reading levels. They also found the number of comprehension strategies used, mastery of phonemic and decoding skills, and attitudes toward reading also improved.

For her doctoral dissertation, Schlag (2009) examined the effects of flexible grouping on reading instruction at the fifth grade level. The study was of a quasi-experimental design measured by a pretest and posttest. Students moved from different reading groups as the readiness level of the student changed. The dependent variable was reading achievement scores measured by the *Standardized Test of Achievement in Reading* (STAR) test. Students took the computerized test every two weeks for the eight weeks of the study and were grouped based on the results. The teacher then instructed the students at their reading level. Schlag found that implementing flexible grouping made a significant gain in reading achievement.

Interestingly the studies that have been done indicate promise for all students. Students with learning disabilities who have low achievement, or are considered gifted benefit the most. Differentiated instruction has its roots in gifted education, but the strategies have also been embraced as a means to support students with learning problems. As Tieso (2005) cited in Rock, Gregg, Ellis, and Gable (2008) reported, many of these studies are qualitative in nature indicating positive emotional outcomes in terms of motivation, task commitment, and excitement about learning.

Riener and Willingham, a psychologist and neuroscientist, respectively, at the University of Virginia, believe that adapting classroom instruction to attend to learning styles is not beneficial. They base this position on at least two arguments. Their research indicates that the brain does not work the way learning style theory suggests. Riener and Willingam (2010) say that if people used auditory strengths to store what they learned in the brain, the result would be the awareness of sound differences, not meaning about math or a novel. They emphasize that students remember meaning, not auditory qualities. They also make an argument against using kinesthetic or visual instructional techniques. Reiner and Willingham have noted that findings that occur in a lab setting with individual learners do not necessarily transfer into classroom practice where there are many variables at work in the learning process; however, Riener and Willingham recognize that people clearly learn in different ways.

Although more stagnant than flexible grouping, Preckel and Brull (2008) found that the self-esteem of gifted females who were ability grouped was lower. The opposite was found to be true with the males who were ability grouped. In the literature review of their study, similar findings were shared by Catsambis, S., Mulkey, L. M., & Crain, R. L. (1999, 2011).

In a review of the literature, Subban included the findings of Hodge (1997) stating an improvement in mathematics achievement but not in reading for students using differentiated techniques for preparing for tests leading Hodge to question whether more traditional approaches are more appropriate during reading instruction. Blozowich (2005) in Subban (2006) found teachers created lessons for differentiating instruction

looked similar to tracking lessons even though teachers used a variety of techniques concluding that continuous professional development along with strong consultation and conversation was necessary. Again, Subban cites research conducted by McAdamis published in the *Journal of Staff Development* in 2001 indicating a significant improvement in test scores in a previously low-scoring district in Missouri. It was reported that teachers noticed that students were more enthusiastic and motivated. It also found that sustaining differentiation would require professional development, mentoring, and time for planning over a five-year period with all levels of administration and teachers involved and dedicated to the change. Subban shares one more finding by Affholder in an unpublished doctoral thesis in 2003. Affholder's investigation concluded that students gained more responsibility, and teachers gained more and more self-confidence as they experienced more success with implementing the techniques. As a result, teachers were willing to try an increased number of strategies. This was especially true of teachers with more experience, knew the curriculum well, and received more extensive training with the methods.

Much of the literature emphasizes the amount of diversity in the elementary classroom. In an example of a mixed-ability classroom, one can find students with learning disabilities, gifted students, students who are socio-economically disadvantaged, children with language needs, and others from a wide range of cultures. Castle, Deniz, and Tortora (2005) contend that differentiated instruction is necessary to meet the varied needs of all students in the classroom. Their study indicated student achievement

improved after experiencing differentiated instruction over several years, but no conclusion could be made regarding the impact of the idea in the classroom.

George (2005) supports differentiated instruction linked with public education and the mixed-ability classrooms in today's schools. The mixed-ability classroom is a reflection of the variety in American society. He goes on to argue that gifted and talented students will not be challenged and will not reach their potential or will become behavior problems due to boredom in the classroom. As students prepare for standardized tests, Tieso (2004) believes interests, abilities, and strengths are in conflict with a one way approach of teaching. As legislation requires programs for the gifted to be implemented, budget restraints place classroom teachers in a position of meeting the needs of these students in a mixed-ability classroom of students.

Beecher and Sweeny (2008) summarize one school's approach to reducing the achievement gap among culturally diverse groups of students through differentiated curriculum and school-wide enrichment teaching and learning. They tell of a school that transformed itself from a plan of remediation to one that enriched students. The approach resulted in improved student achievement and a reduction of the achievement gap between rich and poor and across the various ethnic groups. The school accomplished this by analyzing the strengths and weaknesses in all areas. This resulted in a change in the mission statement, a broad-based instructional strategic plan, specific learning objectives, and detailed action plans. Considering the students' interests and choices, it made sense to the teaching faculty to provide learning experiences that were responsive to the learning characteristics of a diverse student population. The school determined

what would be implemented simultaneously, as well as what would be implemented over a series of years as determined by the strategic plan. Teachers rewrote the curriculum for reading, writing, mathematics, and social studies to include enrichment experiences and differentiated instruction. Although there were enrichment opportunities built into the day, the learning environment extended to an afterschool program inspired by Enrichment Clusters. Staff development was essential to the success of each new initiative, and a significant amount of time was devoted to teacher training. Teachers were provided with training, modeling, coaching, and planning time to integrate the new ideas and skills into their lessons (Beecher and Sweeny, 2008).

While it is not an empirical research study, data were gathered over a period of eight years in which information was drawn from the school's meeting agendas, strategic plan, professional development, and from specific areas of curriculum. The school documented its success through students' positive attitudes about school, increased engagement of learning, and improved achievement on district and state assessments (Beecher and Sweeny, 2008). Graphic data indicated that over a seven year period Asian students improved by over 60%, African-American by over 20%, and White and Hispanic students by over 5%. Students qualifying for free or reduced lunch improved by nearly 30% on state achievement tests.

Tomlinson, Brimijoin, and Narvaez (2008) report on the experiences of two schools on the differentiated instruction journey. Their book indicates the structure of differentiation in each of the schools and survey results in support of differentiation.

Tomlinson (2009) presented results that one of the schools improved steadily in all subjects tested over the three-year period studied.

Through her research on differentiated instruction for her dissertation, Bosier (2007) investigated what research studies have been done on the topic of differentiated instruction in math. The purpose of her research was to 1) review the perceptions of differentiated instruction of upper elementary math teachers as an effective and instructional tool, 2) develop a link between mathematic student achievement and teacher commitment of implementing differentiated instruction in the classroom, and 3) determine teacher perceptions of the advantages and disadvantages of differentiated mathematics instruction. This was a mixed methods study. Bosier compared beginning and ending achievement data in the fall and spring and drew conclusions from the teachers' perceptions.

In a review of studies regarding direct instruction, Gujjar (2007) found students receiving direct instruction in a small group setting performed better in reading, math, and social studies than those in whole group arrangements. Because the groupings are flexible and change as needed, ongoing assessment becomes necessary. Pre-assessment can also be in the form of teacher or textbook created assessments, interest inventories, learning style inventories, and other non-academic instruments.

In her quantitative study published in 2005, Tieso found student mathematics achievement improved based on the effects of three grouping plans on fourth and fifth grade students. In this experimental study she used a design of flexible grouping within the classroom, ability grouping, and the Joplin Plan (grouping based on readiness across

three adjacent grade levels) to investigate the effectiveness. The study was a result of grouping research for gifted students conducted by Pascow (1962), Kulik and Kulik (1982), Slavin (1987), Rogers (1991), and Mills, Ablard, and Gustin (1994). Tieso's study added a new level of complexity with a differentiated curriculum for students who demonstrated mastery of the grade level skills. The comparison group used lessons from the textbook without additional resources. The revision group experienced higher level abstract questions and lessons that crossed into other subject areas. This was a result of the removal of unchallenging and repetitive curriculum. The differentiated group experienced lessons using the principles of a differentiated curriculum. Tieso hypothesized students receiving the adjusted lessons and differentiated curriculum would demonstrate positive gains. Tieso used random assignment of classroom treatment groups and then subdivided into three equal member groups of high, middle, and low using a curriculum based pretest. Teachers who participated in the study were provided with lessons created by the researcher. Posttests followed as the measure of success. The posttests were re-administered three weeks later and indicated that the new learning had positive long-term effects. Other validity concerns were students taking the same forms of the pretest and posttest, sharing ideas among teachers in spite of receiving direction to avoid the temptation, managing groups of students, losing time in students transitioning from one room to another, and teaching materials not being equally distributed.

Tieso's results indicated that flexible grouping combined with a differentiated or revised curriculum positively impacted achievement for gifted students. The findings suggest that teachers need to maintain an active involvement of curriculum, especially for general

education and gifted students. The current curriculum and enrichment opportunities should be meaningful, stretch students' thinking, and build on concepts that are long-lasting.

Walker (2007) includes a positive experience with Dynamic Pedagogy, a curriculum, instruction, and assessment mathematics intervention, seeking to improve students' skills from a conceptual understanding, computational fluency, problem solving, and procedures. In describing the program's five-pronged approach, she references Vygotsky's sociocultural perspective of cognitive development and Sternberg's Triarchic Theory of Intelligence resulting in mixed results as reported by the University of Connecticut's National Research Center on the Gifted and Talented due to clear limitations to the study, including non-random sample and significant interaction between the covariate and grouping variables.

Ongoing assessment and flexibly grouping students based on readiness, interest, learning profile, and prior knowledge are also repeated themes in the literature. Pretesting students prior to starting a unit was a common practice. This type of assessment could be formal or informal. The pre-assessment information provided a path for teachers to follow (Tomlinson, 2001). Students who scored at a mastery level would have their unit compacted. Often the teacher is better able to adjust the pacing, common content, and removal of unnecessary review of skills when pretesting is done (Renzulli & Reis, 2002). This would allow some students to do alternate activities based on interest. Students indicating weak mastery of skills would receive intensive instruction in a small group setting.

Summary

Current understandings on differentiated instruction have primarily been through the work of one expert, Carol Tomlinson; however, the review of the literature includes the work, thoughts, and research studies of this educational approach in combination with others in the field. Considering the review of the literature, a quantitative research study on effectiveness of differentiated instruction is needed. In this continuing age of teacher accountability and quantitative evidence of student achievement, it is necessary to harvest evidence in a similar mode to support a practice to which many teachers in the classroom aspire.

CHAPTER III: METHODOLOGY

Restatement of Purpose

The purpose of this study was to determine the effects of differentiated instruction on student achievement in mathematics. Of the main differentiated instructional strategies, compacting, flexible grouping, and anchoring activities were examined. Most of the studies on this topic have been of a qualitative nature with positive results. This study was quantitative and addressed the following question: Does differentiated instruction impact the growth of student learning in the subject of math?

H_0 = There will be no significant change in student mathematics achievement using differentiated instructional techniques.

The study will also examine if using differentiated instructional techniques impact the growth of student learning in mathematics achievement based on gender differences and ability.

H_1 = There will be no significant change in student mathematics achievement using differentiated instructional techniques between males and females.

H_2 = There will be no significant change in student mathematics achievement using differentiated instructional techniques among ability levels.

This was a study sample of convenience due to the school being accessible to the researcher. It was conducted over four units of study spanning approximately 13 weeks. The four units at the time the study were counting money, money applications, area and perimeter, and fraction concepts. The repeated measures quasi-experimental research

design allowed the researcher to quantitatively investigate the relationship of differentiated instruction on mathematical achievement as a means of increasing growth in mathematics achievement. Additional attention to demographic variables, often thought to influence in mathematics performance, strengthened the design by allowing a deeper analysis of the differentiated instructional activities.

Description of Participants and Setting

Participants were three female teachers. Teacher A has been a second or third grade teacher for fifteen years and holds a Master's degree. She was a former school level Teacher of the Year. Her class of 24 students had 12 boys and 12 girls with four requiring a special education plan in an inclusion setting. Teacher B has 25 years of experience, has been nominated as the school's Teacher of the Year twice and represented the district at the state level. She has always taught primary grades. Her class consisted of 26 students consisting of 12 boys and 14 girls. One of her students is considered an English Language Learner. Teacher C has been teaching for eight years in second grade. Her classroom has 13 boys and 12girls. Four of the students had an individualized education plan in the classroom setting. There were two other teachers in the grade level who did not participate in the study.

The school was in an affluent area of a suburb northeast of Indianapolis, Indiana, with 95.7% of the students' families able to pay for school lunch. During the 2009-10 school year the racial demographics of the school were 84.7% White, 2.3% Hispanic, 3.2% Black, 5.2% Multi-racial, and 4.3% Asian. There were 695 students in grades kindergarten through fourth grade. Third and fourth graders took the Indiana Statewide

Testing for Educational Progress-Plus (ISTEP+) assessment in the spring of 2010. Ninety-seven and four-tenths percents of the third graders and 94.9% of the fourth graders received a passing score in mathematics.

Student participants in the study aligned closely with the demographic composition described above. They had to be second graders between the ages of seven and nine. Students were heterogeneously mixed, including eight who received special education services in an inclusionary model. Children of advanced ability were included. The students' pretest and posttest results for each unit, as well as the aptitude test data and gender were collected and included in the descriptive analyses of the sample. Only data from student subjects who were present at the beginning and end of the research study, and who had parental agreement to participate, were included in order to make valid comparisons.

Procedure

Description of Instrumentation/Measurement Procedures

The effects of differentiated instruction were measured through a repeated quasi-experimental research design. Teachers needed to access not only the pretest and posttest results, but they also needed each of the student's aptitude test results. These were used as a means to explore whether there was a difference among low ability, average ability, and high ability students. The researcher met with the teachers in the study three weeks prior to beginning to review what grade level mathematics topics would be taught. A proposed time line was also presented (Appendix E). Teachers also provided insight as to what units of study would be of similar difficulty for students based on their

experience. The pre- and posttest procedures were modeled for teachers in the form of a pre-assessment of differentiated instructional techniques during the twelve hours of training teachers received. Two separate observations were made before the training as well as during the implementation. The purpose of the first two observations was to determine to what extent teachers understood differentiation. Two thirty-minute observations by the researcher were conducted during math instruction as a means of determining which strategies were implemented. The tally of strategies implemented and observations allowed the researcher to compare these to the change in the pre- and posttest results (Appendix F). A fifth test was given three weeks after the conclusion of two non-treatment units, and a sixth test was given three weeks after the last posttest to the treatment units to determine retention of the skills learned.

Math Assessment

Students were administered four pre- and posttests as well as two cumulative review assessments three weeks after the second non-treatment unit and three weeks after the second unit in which differentiated instruction was implemented. For each lesson or objective of the unit, four or five questions were developed for students to answer. Each unit contained five to six objectives, thus creating a unit assessment of between 21 and 25 questions. Mastery of the skill after instruction was defined to be at 75% accuracy or better. Four or five questions were used to allow for the student to miss one question and still maintain this threshold. Students' mathematics achievement was measured in the form of a researcher created pretest before instruction and repeated again after the full unit instruction had concluded. The cumulative tests had two questions per skill. Unlike

the previous assessments, these tests were summative in nature and served as a tool for determining if the learning experienced was retained. The textbook provided assessments were the primary resource for the questions.

InView Aptitude Assessment

Students were given the InView Cognitive Abilities Test published by CTB/McGraw-Hill. The standard deviation for this assessment is 16. For example a score of 100, which considered average, would have a range of 84 to 116. This is a test given annually to second graders in this school and was used as a means of determining the students' aptitude.

Pre-Treatment Observations

Each teacher was observed for two 30-minute periods before and after training on implementing differentiated instruction. The purpose of the first two observations was to determine to what extent teachers understood differentiation. A tally of differentiated instructional strategies observed was recorded.

Training

The training sessions on differentiated instruction were facilitated by the researcher and took place over a two-day period. The first day focused on the theory behind differentiated instruction and a demonstration of the of the various strategies of differentiated instruction and the foundation including Vygotsky's zone of proximal development and an overview of Sternberg cognitive styles, a second underpinning of differentiation. The strategies were viewed through an Association for Supervision and Curriculum Development training module.

The second day emphasized the strategies of disaggregating assessment data, compacting, flexible grouping, and anchoring activities. Managing a differentiated classroom and the lessons to be used for instruction were included. The lessons were designed and agreed upon by the three teacher participants to reduce the variability of the instruction. A menu of anchoring activities for enrichment was also created. Teachers then planned how to use any help students received from the instructional assistants, including the high school cadet teacher, resources available for anchoring activities to provide additional practice as well as extend the learning, and reviewed for consistency in interpretation of the skills to be taught for the differentiated units.

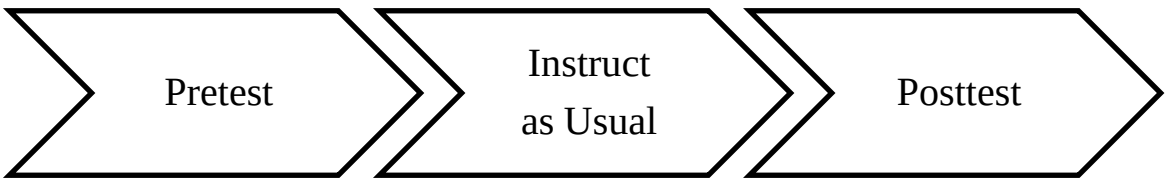
Post-Training Observations

The units of study for differentiation were area and perimeter and fraction concepts. Two observations of approximately 30 minutes each occurred. The two observations during the implementation were done to ensure that strategies presented during the two-day training were being used. One was during the unit on area and perimeter, and the other was during the unit on fractions. A tally of strategies observed was kept.

Research Design

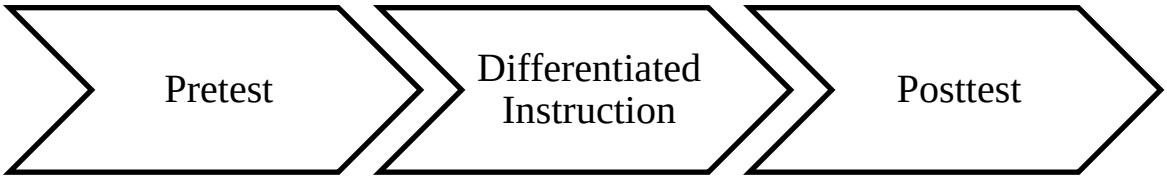
The research design was inspired by a quantitative study published by Tieso (2005). The week before beginning the unit, teachers administered the pretest. After it was scored, teachers had the opportunity to see the results including the responses of the students. This was done twice before the teachers received the twelve hours of training on differentiated instruction over a two-day period. An emphasis of the training included

compacting, flexible grouping, and anchoring activities. Teachers then developed instruction implementing the strategies learned for the next two units of study. Students were grouped based on the InView intervals as a means of determining the level of student who achieved the best in a differentiated classroom. Due to only having participants of average and above average ability in this study, a comparison was made with and without differentiated instruction between these two aptitude ranges. Names were not used and were coded instead. Only students, who were present at the beginning and end of the study and who had completed all four of the pre- and posttests, as well as a minimum of 75% of the instructional experiences, were tracked. The dependent variable was the measure of the pre-and posttest. The independent variable was the differentiated instruction. Internal validity was determined by the comparison of the non-treatment and treatment of the instruction. External validity was determined by the consistency of the results between the two treatments within the same classroom and between the three classrooms. A threat to the construct validity was the level of use of the strategies implemented, the commitment to use the strategies, the researcher's attitude when conducting the training and potentially influencing the teacher attitude, and prior knowledge and experience of the teachers in using differentiated instructional strategies. The process of this experimental design was as follows.



After the twelve hours of differentiated instruction training occurred, the second step was

altered and the process changed as follows.



Description of Procedures

This research study took place over a time period of thirteen weeks through four units of study in mathematics. Approximately one week before the beginning of each of the first two units, a pretest was administered. Teachers were provided with the results in a summative manner and were given the actual responses for each of the questions for each student. Two units were used in order to increase the reliability and validity of the study.

Teachers then engaged in twelve hours of training in differentiated instructional design. The first six hours included an overview of differentiated instruction and the different techniques, including Vygotsky's zone of proximal development and an overview of Sternberg cognitive styles, a second foundational underpinning of differentiation. The second six hours emphasized the strategies of disaggregating assessment data, compacting, flexible grouping, and anchoring activities. Managing a differentiated classroom and the lessons to be used for instruction were included. The lessons were designed and agreed upon by the three teacher participants to reduce the variability of the instruction. A menu of anchoring activities for enrichment was also created.

Teachers administered pretests of four to five questions per skill. Teachers then reviewed the results as a means of flexibly grouping the students for instruction. Students needing direct instruction as indicated by achieving less than 100% on each objective on the pretest met with the teacher. As teachers learned during the 12-hour training, students at this level may be dismissed early from the lesson if the student demonstrated understanding. Teachers implemented the researcher-facilitated designed lessons. Students not in the lesson experienced the enriching anchoring activities. A posttest was given to all students to measure growth. This assessed the impact of the challenging anchoring activities and alternative assignments. The researcher also made two observations of each teacher during the period of differentiated instruction. The tally of strategies implemented and observations allowed the researcher to compare these to the change in the pre- and posttest results.

Data Analysis

The study was implemented with a repeated measures design. The change between pretests and posttests of four mathematics units in three second grade classrooms was compared. The first two units did not have a deliberate attempt to implement strategies associated with differentiated instruction; the second two did. A comparison was made of the following.

Comparison One: The growth (or lack thereof) in mathematics learning in students after two units of non-treatment compared to two units of treatment with differentiated instruction, based on the change from the pretests and posttests using a dependent t-test.

Comparison Two: The growth (or lack thereof) in mathematics learning in students by gender after two units of non-treatment compared to two units of treatment with differentiated instruction, based on the change from the pretests and posttests using a dependent t-test during differentiated instruction.

Comparison Three: The growth (or lack thereof) in mathematics learning in students with differing ability after two units of non-treatment compared to two units of treatment with differentiated instruction. This will be based on the change from the pretests and posttests using a dependent t-test of two ranges of scores from the InView Cognitive Abilities Test during differentiated instruction. The average range is between 86-114, and the above average range will be any score greater than 114.

A comparison by special education, English Language Learners, poverty level, or ethnic or racial diversity was not done due to the school not having a large enough number of students in any of these subgroups.

A finding was considered significant at a 0.05 level for all three comparisons. These analyses needed to be conducted at the classroom level due to the lack of random assignment of the students to classrooms since students with special needs were clustered together for ease in providing services.

To determine the significance of growth from non-treatment to treatment, the following formula was applied:

m equals the average growth of each pre- and posttest combination. M equals the mean of each variable before and after treatment.

$$M_{Before} = (m_{Unit\ 1} + m_{Unit\ 2})/2$$

$$M_{Treatment} = (m_{Unit\ 3} + m_{Unit\ 4})/2$$

$$M_{After} = (m_{Retention\ 1,2} + m_{Retention\ 3,4})/2$$

To accommodate for the small sample of three classroom teachers, an effect size analysis was done. The effect size was calculated as follows.

$$Mean_{Difference} = (Mean_{Treatment} - Mean_{Before})$$

$$SD_{pooled} = (SD_{before}\ n_{before}) + (SD_{treatment}\ n_{treatment}) / (n_{before} + n_{treatment})$$

$$Cohen's\ d = M_{difference} / SD_{pooled}$$

A second effect size was determined for retention of skills learned and was calculated as follows.

$$Mean_{Difference} = (Mean_{Retention\ 3,4} - Mean_{1,2})$$

$$SD_{pooled} = (SD_{Retention\ 1,2}\ n_{Retention\ 1,2}) + (SD_{Retention\ 3,4}\ n_{Retention\ 3,4}) / (n_{Retention\ 1,2} + n_{Retention\ 3,4})$$

$$Cohen's\ d = M_{difference} / SD_{pooled}$$

The value of Cohen's d effect size fell into one of the following levels of effectiveness.

< 0.2 = not effective

0.2-0.8 = moderately effective

> 0.8 = highly effective

The test of retention was a comparison of the average of the two tests, one cumulative after the first two units without differentiation and the second after the treatment of differentiated instruction included. The pretest and posttest change as a

result of the training and the implementation of differentiated instuction was simply reported as the mean percentage increase or decrease.

CHAPTER IV: RESULTS

Restatement of the Research Questions

The hypothesis in this study was that differentiated instruction does improve the growth of academic achievement. This study looks at the results, not only in terms of the second grade students as a whole, but also gender and ability. Quantitatively this was measured by comparing instruction that does not differentiate based on growth data with instruction that does, using pre- and posttests. The following three null hypotheses were stated as:

1. There will be no significant change in student mathematics achievement using differentiated instructional techniques.
2. There will be no significant change in student mathematics achievement using differentiated instructional techniques between males and females.
3. There will be no significant change in student mathematics achievement using differentiated instructional techniques among ability levels.

Does differentiated instruction impact the growth of student learning in the subject of math?

In order to determine whether or not differentiated instruction impacted student learning in mathematics, the mean difference in pretest and posttest scores was calculated for the two units implemented without and with differentiated instruction (Table 1).

Table 1 *Comparison of Pretest and Posttest Change Before and After Treatment*

Condition	n	Percent Diff. of Unit 12 Pre- and Post	Percent Diff. of Unit 13 Pre- and Post	Avg. Pct. Chg. of Units 12 and 13	Percent Diff. of Unit 25 Pre- and Post	Percent Diff. of Unit 26 Pre- and Post	Avg. Pct. Chg of Units 25 and 26	Avg. Pct. Chg of Units 25 and 26 and Units 12 and 13
OVERALL	61	41.77	34.63	38.20	41.80	36.54	39.17	+0.93
Female	31	47.86	35.06	41.46	41.65	37.15	39.40	-2.06
Male	30	41.87	27.27	34.83	39.76	38.08	38.92	+4.09
Avg. Aptitude	36	41.19	42.67	41.93	37.30	34.78	36.04	-5.89
Above Avg. Aptitude	25	32.92	32.10	32.51	46.55	42.59	44.57	+12.06

A relationship of the mean of the two units of study prior to implementation compared with the two after implementation showed a 0.93% increase from the average pre-treatment change to the treatment change when viewing the last column of Table 1.

Students also took an assessment approximately three weeks after the conclusion of the second unit (Unit 13). The same process occurred after Unit 26, the second unit of the treatment. The results are shown in Table 2. The purpose was to determine the retention of the material learned. There was a positive change of 3.17% from Cumulative 1 to Cumulative 2.

A dependent sample t-test was conducted to determine if there was a significant difference in the average changes in scores between the pretreatment units (12 and 13) and the two units after training in differentiated instruction was conducted. The results of the change between pretreatment and treatment instruction were not significant at the 0.05 level as demonstrated in Table 2; (mean = 39.17, SD = 1.68; $t = .33$, $p > .05$).

Table 2 *Mean Changes of Pretreatment and Treatment and Cumulative Tests (Overall)*

		Change After Differentiated Instruction		Change Before Differentiated Instruction		Results of t Tests		
Condition	*n*	M_2	SD_2	M_1	SD_1	*t*	*df*	$p_{.05}$
Overall Chg of 25 and 26 from 12 and 13	61	39.17	1.68	38.20	1.36	0.33	60	< .74
Overall Cum. Test 2 from Cum Test 1	61	87.05	1.34	83.88	1.37	1.81	60	< .08

Notes: 1 reflects pretreatment units 12 and 13 or CUM 1; 2 reflects treatment units 25 and 26 or CUM 2

A dependent t-test was conducted to determine if there was a significant difference in the scores on the two cumulative tests which was administered approximately three weeks after instruction. Two questions per skill taught in the units were on the assessment. The results of the change between pretreatment and treatment were not significant at the 0.05 level as demonstrated in Table 2; (mean = 87.05, SD = 1.34; t = 1.81, p > 0.05).

When comparing the pretreatment units to the treatment units, the implementation of differentiated instruction was found to be relatively ineffective, ES=0.04. The cumulative assessments indicated a low effectiveness, ES=0.23. Table 3 reflects this.

Table 3 *Statistical Comparisons Before and After Treatment of Unit Paired Tests and Cumulative Tests*

Condition	N	Percent Change	SD_1	SD_2	Cohen's d
Difference between mean of two non-treatment units and the two treatment units	61	+0.93	1.36	1.69	.04
Difference between mean of cumulative tests of non-treatment and treatment	61	+3.17	1.37	1.35	.23

Notes: 1 reflects pretreatment units 12 and 13 or CUM 1; 2 reflects treatment units 25 and 26 or CUM 2

Based on the low effect size and the result of the comparison of the unit test pairs, and the cumulative tests, differentiated instruction did not have an impact on the learning of students in general, and the null hypothesis is accepted; ($t = 0.33$, $p > .05$).

Does differentiated instruction impact the growth of student learning of a particular gender in the subject of math?

Thirty-one females and thirty males participated in the study. In order to determine whether or not differentiated instruction impacted student learning based on gender in mathematics, the mean difference in pretest and posttest scores was again calculated for the two units implemented without differentiated instruction and for the two units implemented after differentiated instruction (Table 4).

Table 4 *Mean Changes of Pretreatment and Treatment and Cumulative Tests (Gender)*

		Change After Differentiated Instruction		Change Before Differentiated Instruction		Results of t Tests		
Condition	*n*	M_2	SD_2	M_1	SD_1	t	*df*	$p_{.05}$
Female Chg of 25 and 26 from 12 and 13	31	39.40	1.69	41.46	1.30	-0.48	30	< .63
Male Chg of 25 and 26 from 12 and 13	30	38.92	1.71	34.83	1.36	1.02	29	< .32
Female Cum 2 Test and Cum 1 Test Average	31	84.84	1.70	81.86	1.52	1.59	30	< .12
Male Cum 2 Test from Cum 1 Test	30	89.33	0.81	85.97	1.18	1.59	29	< .12

Notes: 1 reflects pretreatment units 12 and 13 or CUM 1; 2 reflects treatment units 25 and 26 or CUM 2

In viewing Table 4, there was a slight decrease in female test scores from before to after treatment. Male change performance increased 4.09% after differentiated instructional strategies were implemented in the mathematics instruction.

A dependent t-test to determine if there was a significant difference in the average changes in scores between the pretreatment units (12 and 13) and the two units (25 and 26) after training in differentiated instruction was conducted based on gender. The result of the change between pretreatment and treatment for females was not significant at the 0.05 level as demonstrated in Table 4; (mean = 39.40, SD = 1.69; $t = -0.48$, $p > 0.05$). In fact, differentiated instruction appeared to be detrimental; however, for males, it was not harmful, but the results of the positive change for males between pretreatment and treatment were not significant at the 0.05 level as demonstrated in Table 2; (mean = 38.92, SD = 1.71; $t = 1.02$ $p > .05$).

A dependent t-test to determine if there was a significant difference in the scores on the two cumulative tests that were administered approximately three weeks after instruction for the purpose of analyzing the effect of differentiated instruction in mathematics on gender. Two questions per skill taught in the units were on the assessment. The results of the change between pretreatment and treatment were not significant at the 0.05 level for either males or females.

The comparison of female results as indicated in Table 4 was consistent when reviewing the cumulative tests and comparing them to the end-of-unit tests; (mean = 84.84, SD = 1.70; $t = 1.59$, $p > .05$).

The comparison for males proved to be more positive when reviewing the change of unit averages and the cumulative averages and comparing them to the end-of-unit tests averages; (mean = 89.33, SD = 0.81; $t = 1.59$, $p > 0.05$).

Neither males nor females had significant growth when comparing the cumulative test change to the paired unit tests when differentiated instruction was implemented. When looking at the results of both cumulative assessment results, the null hypothesis is accepted indicating that differentiated instruction does not benefit one gender over the other. Similar results were found with either analyzing the paired unit assessments or the cumulative assessments.

Does differentiated instruction impact the growth in mathematics learning of students with differing aptitudes?

In order to determine whether or not differentiated instruction impacted student learning in mathematics based on ability, the mean difference in pretest and posttest scores was calculated for the two units implemented without differentiated instruction and for the two units implemented after differentiated instruction (Table 5).

Table 5 *Mean Changes of Pretreatment and Treatment and Cumulative Tests (Aptitude)*

		Change After Differentiated Instruction		Change Before Differentiated Instruction		Results of t Tests		
Condition	*n*	M_2	SD_2	M_1	SD_1	t	*df*	$p_{.05}$
Avg. Aptitude Chg. of 25 and 26 from 12 and 13	36	36.04	1.68	41.93	1.31	-1.76	35	< .09
Above Avg. Aptitude Chg. of 25 and 26 from 12 and 13	25	44.57	1.65	32.51	1.32	2.40	24	<.04
Avg. Aptitude Cum 2 Test and Cum 1 Test Average	36	84.86	1.59	86.34	1.16	-.744	35	<.46
Above Avg. Aptitude Cum 2 Test from Cum 1 Test	25	90.22	0.86	79.16	1.58	4.00	24	<.01

Notes: 1 reflects pretreatment units 12 and 13 or CUM 1; 2 reflects treatment units 25 and 26 or CUM 2

The population of the subjects did not garner any students with an aptitude score below 85. Consequently, only two ranges of aptitude, average (85-114) and above average (115+), were compared. Table 5 indicates that students of average ability did not do better on the post assessment after teachers received training in differentiated instruction; however, students with above average ability increased by over 12% after teachers implemented the differentiated instructional strategies.

A dependent t-test to determine if there was a significant difference in the average changes between the pretreatment units (12 and 13) and the two units (25 and 26) after training in differentiated instruction was conducted based on aptitude. The result of the

change between pretreatment and treatment for students with an average aptitude was not significant at the 0.05 level as demonstrated in Table 5; (mean = 36.04, SD = 1.68; t = -1.76, $p > 0.05$). However, there was a significant difference between the pretreatment and treatment for students with above average ability as found in Table 5; (mean = 44.57, SD = 1.65; t = 2.40, $p < 0.05$).

A dependent t-test to determine if there was a significant difference in the change of the two cumulative tests was also administered approximately three weeks after instruction for the purpose of analyzing the effect of differentiated instruction in mathematics based on aptitude. Two questions per skill taught in the units were on the assessment. There was not a significant difference in the growth of average students for math instruction with differentiated instruction; (mean = 84.86, SD = 1.59; t = -0.74, $p > 0.05$). However, the results of the change between pretreatment and treatment were significant at the 0.05 level for above average ability students, indicating that there was a significant difference in the growth of above average students for math instruction with differentiated instruction; (mean = 90.22, SD = 0.86; t = 4.00, $p < 0.05$).

Table 5 displays the results of the unit and cumulative tests. The comparison of students with average aptitude results was consistent when reviewing the cumulative tests with the end-of-unit results. The comparison for students with an above average aptitude proved to be significant when reviewing the change of unit averages and the cumulative averages.

Above average students had significant growth when compared to average students in a differentiated classroom when both short-term and long-term learning were

analyzed. When looking at the end of-unit results and cumulative assessment results, the null hypothesis is rejected indicating that differentiated instruction benefits one ability level over the other. In this study, it was above average students who made greater improvement.

Summary of the Results

Overall, students did not make significant improved change after differentiated instruction was implemented. This was evident in the assessment of students at the conclusion of the two units serving as the curricula for measuring the change, as well as when the skills were assessed for long-term understanding. The low to moderate effect sizes measures also indicate this.

When considering gender, there was not a significant difference in growth of males and females when using the end-of-unit assessment or the cumulative assessments, which indicates that neither females nor males significantly benefited when examining the long-term effects when compared to each other.

Based on the two aptitude ranges studied, the end-of-unit assessments indicated that students with above average aptitude benefited from having differentiated instructional strategies implemented as indicated by the improved change in results on both the paired units compared and the cumulative assessments. The same was not true of average ability students. These students did not demonstrate a significant increase in growth when examining the paired units as well as those given three weeks later.

While average ability students did not make significant improvement after the implementation of differentiated instruction, students with above average ability made

significant growth on the paired units and cumulative assessments. While the findings are mixed in this particular study indicating a significant improvement for students with above average ability but not for those with average ability, it is important to continue the examination of differentiation in the classroom as a means of improving student achievement.

More study of differentiated instruction and gender would be a good area for further analysis to determine the consistency of this conclusion. Further study on this idea would advance the field of education and student response to instruction. More study of differentiated instruction and aptitude would be a good area for further analysis to determine the consistency of the conclusion that students with above average ability benefit greatly from this instructional technique.

CHAPTER V: CONCLUSIONS AND DISCUSSION

Introduction

American schools are faced with an ever increasing number of students from a wider range of backgrounds. Teachers are under tremendous pressure to ensure that all students learn at a minimum level as assessed by high stakes testing procedures. Differentiated instruction has been thought over the years to be the instructional design that will overcome these challenges. Most studies conducted have been of a qualitative nature, indicating that students feel better about school and teachers believe that students are learning more and at required levels. With the emphasis on quantifiable data to demonstrate improving student achievement, it is necessary to analyze differentiated instruction as an approach that can be proven effective with specific data.

This chapter includes the purpose of the investigation with a restatement of the guiding research question. It will also review the results of the subgroups analyzed as well as the conclusions, discussion of results, limitations of the study, recommendations for future research, and a final summary. The focus remains on the following questions:

Does differentiated instruction impact the growth of student learning in the subject of math?

Does differentiated instruction impact the growth of student learning of a particular gender in the subject of math?

Does differentiated instruction impact the growth of student learning of a particular aptitude in the subject of math?

Summary of the Study

The purpose of this study was to determine the effectiveness of differentiated instruction. The subject area was mathematics at the second grade level. The study was inspired by a study on differentiated instruction conducted by Carol Tieso (2005), which looked at the performance of students at the upper elementary grade levels.

A quasi-experimental method was chosen to investigate the questions. This was in part due to having the convenience of the school and the willingness of teachers to participate. The teachers participating in the study were eager to learn about differentiated instruction and potentially experience new strategies to meet the range of abilities in their classrooms.

In general, the overall findings indicate that differentiated instruction does not significantly improve the growth of student achievement. Students with above average ability demonstrated improved change at a significant level. Females, males, and average ability students did not demonstrate significant growth when differentiated instructional strategies were implemented based on the paired unit change comparisons.

Discussion of the Results

Summary of Results

The results of the study do not support the literature indicating that differentiated instruction impacts student achievement positively. The exception is that differentiated instruction improves student achievement in mathematics for the subpopulation of students with above average ability.

Even with the varied ranges of students within average ability, the implemented strategies of differentiated instruction sustain these students and did not make a significant difference. Based on conversations between the researcher and teachers during the training for implementing differentiated instruction, it became evident that interpretation of mathematical skills, the interpretation of the rigor, and expected outcomes among the teachers varied. Two of the three teachers admitted that they concentrate much of their teaching efforts on the neediest students in the class and were often dissatisfied with how to enrich the performance of their most capable students. The third teacher felt she had an awareness of the varied needs in her classroom and provided challenging activities, but she did not think she was doing enough for students with above average ability.

Teachers' attitudes for providing differentiated instruction were positive, but strong leadership and longitudinal commitment for implementing it are needed. Such dedication would support teachers with time for collaboration and discussion of learning expectations. Changing from long-time practices to focusing on differentiating to meet the various needs in the classroom takes time and continuous professional development. Based on what the teachers in the study shared, students with above average ability become at risk in a classroom where opportunities to extend or expand skills are not present due to the time and energy given to students with average ability. As a result of being a part of this study, the teachers were starting to think about planning units that included ways to challenge students with a higher academic level first and then think about how to adjust the instruction so that it was attainable to the average students.

While not necessarily experienced in this study, the same might be true for students with below average ability. What the teachers shared was consistent with much of what has been written by Carol Tomlinson (1995, 2001, 2003, 2009).

This study examined the effectiveness of differentiating the instruction in the elementary mathematics classroom. Allowing students to grow in their academic endeavors as seen in academic gains should be the goal for all students regardless of where they start at the beginning of a unit of study. An analysis of academic growth for subgroups based on race and socio-economic status was not done in this study, however; there is some research indicating the benefits of differentiated instruction on these subgroups. Beecher and Sweeny (2008) published a research study indicating that over a seven year period Asian students improved by over 60%, African-Americans by over 20%, and White and Hispanic students by over 5% on state achievement tests. Students qualifying for free or reduced lunch improved by nearly 30% on state achievement tests. Repeating this research design with a more diverse population of students is suggested for the purpose of determining whether outcomes replicate the findings of Beecher and Sweeney.

This study examined whether one gender benefited over the other when differentiated instruction was implemented. Neither male nor female students demonstrated greater achievement at a significant level at the end of a unit of study or over the long-term. Considering the review of the literature, there were few prior findings in this subcategory of gender (Preckel and Brull, 2008). What has been written leans toward examination of self-esteem as opposed to achievement. More study is

warranted regarding this research question. A future study might incorporate Sternberg's Triarchic Theory of Intelligence (1997) emphasizing analytical, creative, and practical thinking styles but with an emphasis on gender differences as it relates to the theory. This would be important in finding whether one gender indicates a preference for one of Sternberg's thinking styles over another, thus allowing teachers to differentiate the instruction to better match thinking styles and gender.

Students in this study with above average ability were found to benefit significantly when mathematics instruction was differentiated. Tieso's 2005 study also found that students with a higher ability benefitted from differentiated instruction at a significant level. One will want to consider if differentiation supports average students during immediate learning experiences and long-term retention in spite of not performing as well at the end of a unit of study. More research needs to be done in this area. In this manner of thinking, differentiation may indeed indicate a higher level of growth for this level of student.

Limitations of the Study

This was a study sample of convenience. It was conducted over four units of study spanning approximately 13 weeks. The study might have been more comprehensive if it could have been fully experimental with an increased number of classrooms serving as a control group and the same number serving as an experimental group. An increased number of participants might also have garnered more accurate findings. A larger sample with a more diverse population would allow for a broader examination of special populations such as special education, ethnicity, and

socioeconomic status. The selected units were recommended by the teachers, but these units were also followed the progression of the school's scope and sequence at the time the study was conducted. Rather than four units of study, an increased number of units spanning over more skill areas of mathematics over an extended period of time might have also indicated different results.

Specific to this study, general threats to the validity of this design are the ability to take these results and apply them to any population; however, it is possible to replicate the quasi-experimental design in a different setting. A potential internal validity concern is the limit in which students may change positively or negatively. If the baseline was extremely low, then the positive change could be greater. Likewise, if the baseline was extremely high, the potential to change positively is limited since the best score possible has a ceiling of 100. These students could also have a substantial negative change. No students achieved a perfect baseline score, but there were incidences of students having a baseline score of zero. A score of zero indicates that the subject was not able to answer any of the questions or did not take the assessment seriously.

Recommendation for Future Research

The purpose of this study was to find out if differentiated instruction was effective in the elementary mathematics classroom. Not only did the study look at the overall effectiveness of differentiated instruction, but it also examined the two subgroups of gender and ability. The classrooms in the study did not have enough subjects who were of below average ability, received free or reduced lunch, received special education services, or who represented diverse racial groups to produce enough confidence in the

findings. The results indicated that differentiated instruction did not significantly impact the achievement of students. There was not a significant difference between females and males, but students with above average ability did significantly better than students whose ability was considered to be average.

Castle, Deniz, and Tortora (2005) contend that differentiated instruction is necessary to meet the varied needs of all students in the classroom. Their study indicated student achievement improved after experiencing differentiated instruction over several years, but no conclusion could be made regarding the impact of the idea in the classroom. While it is not an empirical research study, Beecher and Sweeny (2008) were able to conclude over a seven year study that Asian students improved by over 60%, African-American by over 20%, and White and Hispanic students by over 5%, and students qualifying for free or reduced lunch improved by nearly 30% on state achievement tests. This is an area suggested for more quantitative research.

It might be beneficial to have a study take place over a longer period of time with ongoing training and support, including interpretation of assessment data to drive instruction. While these teachers demonstrated skill in managing a differentiated classroom with ease, it might not be the case in every circumstance. The factors of class size and ages of students should be researched more deeply. Differentiated instruction is very complex and challenging to implement in a brief period of time. Although the teachers in this study received twelve hours of training, it really is just the gateway to expanding to other strategies often associated with differentiating instruction. To

implement it deeply and across multiple subjects takes many years and challenges a teacher to seek more ways to respond to student learning needs.

In order to further investigate the impact of differentiated instruction on students, additional study will want to be done with students of a similar aptitude as well as students of below average ability and of varied ethnicity and socioeconomic levels. Much of the research supporting differentiated instruction can often be found in professional journals focusing on gifted and talented education. Differentiated instruction has a solid body of research supporting the practice for students with above average ability. This is evident in the findings of Tieso (2005) and Beecher and Sweeney (2008).

The literature review produced little research regarding gender differences and differentiation. The results of this study indicated two similar and related outcomes indicating that differentiated instruction does not significantly improve the achievement of either gender. The 2007 TIMSS indicated that females continued to fall behind males in mathematics achievement. This study did not find that differentiated instruction would change this trend. Further study is recommended with this subgroup for consistency of the results.

This study and the one conducted by Tieso (2005) dealt with elementary students. Tomlinson has researched the middle school environment and co-authored a book chronicling the differentiated instruction experience at an elementary school and high school. This study did not include or present data regarding the use of differentiated

instruction at the secondary level. This is an area of the education system deeply needing more consideration.

Implications for Practice

Differentiated instruction has been thought to increase achievement and close the achievement gap. While much has been written about the theory behind differentiated instruction, there has been a lack of deep understanding in how to fully implement it. There have been books written on differentiated strategies for quick and easy implementation as well as professional development workshops created. Many of these lack a cohesive connection of theory with implementation.

The teachers in this study were engaged in twelve hours of training in differentiated instructional design. The first six hours included an overview of differentiated instruction and the different techniques including Vygotsky's zone of proximal development and an overview of Sternberg's cognitive styles, a second foundational underpinning of differentiation. The second six hours emphasized the strategies of disaggregating assessment data, compacting, flexible grouping, and anchoring activities. Managing a differentiated classroom and the lessons to be used for instruction were also included. The lessons were designed and agreed upon by the three teacher participants to reduce the variability of the instruction.

Observations of the three teachers were completed before the training and after. The purpose of the two observations before the training were to secure a baseline of any differentiated strategies currently used by any of the teachers. A tally of these was kept over each of the thirty-minute visits. The process was repeated after the training but for

the purpose of ensuring that the strategies that were taught to the teachers were being implemented with fidelity. While not directly related to the research questions, it is interesting to consider these observations in light of implications for practice and the importance of providing training for teachers when implementing new strategies.

Observations Before Implementation of Differentiated Instruction

One of these teachers, Teacher A, was observed giving students who met the objective of the day's lesson based on the pretest results the opportunity to experience an independent activity at a more challenging level with a more in-depth practice assignment for the day. The intent was to give students with greater ability a challenge. The students were offered a choice from approximately eight options from previously taught concepts. These were usually in the form of a game, Pentominoes, or puzzles and largely represented on grade level practice as well as extensions if chosen by the student.

Teacher B utilized a cadet teacher from the local high school to work with a small group of students on a computation skill and three-column addition at an advanced level. She pulled five students after presenting the original lesson to review subtraction facts with flashcards while the rest of the class was working on the independent assignment. This occurred for approximately four minutes. Teacher B had also created a special day during one of the observations centered on money. She reported students did money rubs resulting in a picture and playing a computerized game from their Harcourt Publishers mathematics textbook series called *Lulu's Diner*. This is a leveled computer program with over 20 entry points for instruction. It was not clear whether all students experienced the same level of lesson or not.

Teacher C assigned students an activity to complete after finishing the independent activity. These were often hands-on materials with reinforcement of activities of the current unit of study. During both observations, there was a flurry of activity. She presented the lesson to the whole group and slipped in some more challenging questions as a preview of future lessons. The independent practice worksheet used was the same on one side for all students and varied on the backside. The unit topic was money. The on grade level students had pictures of the coins to count. The challenge group had the names of the coins (two quarters, one dime, one nickel) and had to find the sum of them. While students were working at their seats, Teacher C also worked with a small group of students with math facts.

The three teachers reported sharing ideas and strategies with each other on a regular basis, but they differed in the level of rigor interpreted by the skill to be developed. This became apparent when the pretest was administered. Two of the teachers felt the number of questions on the assessment was too overwhelming but gave the pretests and posttests as directed by the researcher. When the discussion included the importance of having enough question prompts to confidently determine that students had mastery of the skill, all three teachers were excited to have common assessments communicating formative information. This variance of expectations is an impetus for further research regarding the collaborative interpretation by the teachers.

Observations During Implementation of Differentiated Instruction

Strategies observed were flexible groups, anchoring activities at multiple levels, and compacting. Teachers were also observed assigning varied activities, something

done as a result of the training. While this strategy was not emphasized to the group, it was presented as one of a group of strategies. It was obvious that teachers latched onto this approach and were able to implement it successfully. The two teachers with instructional assistants for supporting the special education students used these staff members for keeping students on task and for reinforcing skills in small groups. Instructional assistants also supported the teaching by duplicating the whole group lesson to a smaller group of students.

During a fraction lesson, Teacher A taught approximately half of her class the lesson based on the results of the pretest data. The instructional assistant, delegated for the students with special needs, had the other half of the class who demonstrated mastery of the day's lesson, including one of the students she was there to support, participating in alternate activities. These activities included Marcy Cook Math Try-A-Tiles for telling time and shapes, manipulative spatial materials, and problem solving. These materials required the students to use advanced thinking skills. These students were enthusiastically engaged, shared ideas, and were on task. The students with Teacher A were equally engaged in the hands-on activity regarding fractions as part of a whole. Based on the number of students wishing to participate and interact, students had a solid understanding of the concept. Based on the unit test over this skill, all but one of the students in the study mastered it with at least 75% correct.

During the implementation of differentiated instruction there was a heightened use of Howard Gardner's Multiple Intelligences as noted by the use of a rap and chants to define perimeter by Teacher B. Her anchoring activities, much like that of a learning

center, were a combination of review activities, games of a kinesthetic nature, and higher order thinking of some of the previously learned skills. Before the training, this teacher used hands-on activities of a similar difficulty level.

Teacher C made the greatest metamorphosis as a result of the training. It was clear that the pre-assessment data was used to flexibly group her students. Students were organized in such a way that utilized the instructional assistant to oversee the work of the students completing challenging activities. Teacher C met with multiple groups of students to present the same lesson at two different levels of rigor. Students with the greatest demonstration of understanding were given tasks that allowed them to consult with a neighbor if needed with the expectation that she would be available to help between the two groups of students receiving direct instruction. The body language of the challenge group included a furrowed brow, twirling of bangs, and expressions of determination. The classic, "Ah," when a student learned something she scaffolded to understanding, was evident. Teacher C also reported that she used the techniques from the training on a unit study prior to teaching the two units observed.

If the response to the training can be generalized and teachers in the study are representative of typical American teaching teams, then there is a need for teachers to 1) agree upon the interpretation of the curriculum standards, 2) work in collaboration to ensure greater success in creating a learning environment for all students to be successful at their level, 3) share in the responsibility and thereby create a manageable learning atmosphere with clear routines and expectations, 4) learn how to enrich those students who can demonstrate mastery of skills, 5) scaffold instruction for those who need

support, and 6) create a culture of collegiality in an effort to make differentiation a success equitably across the school.

Professional development, similar to the twelve hours the teachers in the study received, would better support a differentiated classroom that would respond to the instructional needs of students (Tomlinson, 1995). Based on the results of this study and the feedback the teachers provided as a result of the training and the changes made in instructional practice, differentiated instruction can impact the achievement of students, significantly for those students with a higher aptitude. According to the teachers, participation in the study made them more aware of students' various needs, and they were better able to address those because of the experience. They felt that the focus of their teaching had often been on the students experiencing the most difficulty, and they tended to assume that the students who learned concepts and skills easily would progress satisfactorily. Using pre-assessment data was an eye-opening experience for the teachers who were not using it regularly as a means of driving instruction. This was especially true when the pretest results indicated that students already had mastery of specific skills before the unit was started. It affirmatively solidified the suspicion that some students knew much of the material before the unit was started. The teachers also indicated that what they learned in this study will continue after the conclusion of the experience.

Administrators must do more than tell teachers to differentiate instruction. They must provide long-term professional support. As was the case with the teachers in the study, once they were able to understand the pretest data, disaggregate it, problem solve together, and share ideas and materials, differentiation was able to be implemented

successfully. The training they received was a start, but there needs to be an opportunity for them to have deeper study, share their experiences with other colleagues, and participate in a peer coaching model of feedback and celebration. The building administrator must keep differentiation as an ongoing growth initiative rather than the "thing being done for this year" in an attempt to make a difference. Many teachers have some understanding of differentiation, even if just a familiarity of the term. Administrators must hold it at the forefront if it is to be truly successful.

Much of the research supporting differentiated instruction can often be found in professional journals focusing on gifted and talented education. This study would add to the writings and thoughts of experts in this field. As schools are facing budget reductions and higher ability programs are often one of the programs impacted, this study could be used as evidence as to why these programs need to continue to exist and at the very least train teachers in strategies that allow the students with above average ability to thrive and grow in the general education classroom.

Final Summary

The overall results of this study indicated that differentiated instruction did not have an impact on academic achievement in mathematics in the elementary classroom. This finding was also true when examining whether one gender benefitted more than the other. Aptitude of average and above average students was also studied. In this study, differentiated instruction for mathematics was shown to have a positive impact on student achievement for students with an above average ability.

Because there is little prior quantitative research on the subject of differentiated instruction, it would be difficult to say that this study supports or refutes the use of it in the elementary mathematics classroom. However, when compared to much of the qualitative research, this quantitative study does not support the findings in the qualitative studies. The same is true of the findings of gender. There is little research on differentiated instruction regarding gender, so this early finding would be important. Positively speaking, this study did not find that differentiation benefits one gender over the other indicating that neither gender benefits from or is harmed by its implementation.

Students with above average ability were found to benefit from differentiated instruction at a significant level. Much of the published research in support of differentiation can mostly be found in materials often associated with gifted education. This study proved to have similar findings, and there is a substantial amount of qualitative nature to support it. The Tieso (2005) study of grouping in mathematics had results similar to those in this study.

More work in the area of understanding assessment and managing multiple activities in the classroom is needed. Students interacting with anchoring activities, participating in flexible groups, and completing tiered assignments are examples of the high engagement in a differentiated classroom, and even teachers with some level of comfort with varied instructional activities, would benefit from more training. This study included twelve hours of professional development, and the results of what teachers took away from the experience were evident in terms of the benefit it provided for the above average students. More learning experiences for teachers beyond the twelve hours used

in this study are recommended since differentiated instruction is complex. It might also allow students of all ability to benefit and grow. This might have happened in this study if more time were given to specifically address students of greater academic need.

While the observations of the teachers in the study were done with the intent of determining the baseline of instructional practices and the ensuring the fidelity of implementation after receiving the training, it also provided some insight to their understanding of assessment, collegiality, and common expectations of students in the grade level. The teachers in this study demonstrated a range of differences in instructional approaches, and they were not consistent in their understanding or implementation of adjusting instruction to meet the varied academic needs of the students. With the brief amount of training they received, they were able to discover that working collaboratively, learning to use common assessment data, and readjusting the ways in which they used certain materials would help more of their students. They were also able to rethink how they use any additional personnel in their classroom. The teachers were now using the extra pair of hands, often in the form of an instructional assistant, to help with students who were working at or above grade level as a management tool for independent and challenging activities, freeing them to provide the direct instruction to those students who need it the most. All of the teachers used the assessment data, including the pretests and posttests to develop learning paths, both enriching and instructional, to better meet individual needs. While all of the teachers informally reported that participation in the study helped to improve their instruction in mathematics, the two teachers with the least experience with implementing

differentiation indicated that they found what their students learned and how they met those specific needs.

In general, this study has not shown that differentiated instruction improves academic achievement at a significant level with the exception of students with an above average aptitude. These students did make significant improvement when differentiated instruction was implemented. Differentiation has long been thought to have promise for reducing the achievement gap. It is vital that continued study be done to best evaluate the practice for all.

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APPENDIX A

Section I

Title.

The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom

Purpose.

The purpose of this study is to determine the effects of differentiated instruction on student achievement in mathematics. Of the main strategies, compacting, flexible grouping, and anchoring activities will be examined.

Rationale.

Differentiated instruction is a term commonly used in education as a means of creating non-traditional teaching approaches. While differentiated instruction has been a part of teaching practice for many years, it has received more attention as showing great promise for narrowing the achievement gap in students and respecting students' strengths and talents.

Many references in the literature include easily found research studies conducted by Joe Renzulli, Carol Tieso, Sally Reis, and Robert Slavin. Many of these go back as far as the early 1970's. Other reviews of the research cite Lev Vygotsky's theory of zone of proximal development (ZPD) and Carol Ann Tomlinson as well as the aforementioned researchers. Vygostsky's theory is based on the idea that students will achieve the best when faced with tasks or engaging learning experiences slightly above what they can do independently. Castle, Deniz, and Tortora (2005) promote differentiated instruction is necessary to meet the varied needs of all students in the classroom. Their study indicated student achievement improved after experiencing differentiated instruction over several years, but no conclusion could be made regarding the impact of the idea in classroom. George (2005) supports differentiated instruction linked with public education and the mixed-ability classrooms in today's schools. The mixed-ability classroom is a reflection of the variety in American society. He goes on to argue that gifted and talented students will not be challenged and potentially will not reach their potential or will become behavior problems due to boredom in the classroom. Tomlinson would be considered to be the most contemporary authority on differentiated instruction. She has written several books, has authored or co-authored many article in educational journals, and is a featured speaker at education conferences. Others have published books using her framework and applying the concepts into practical classrooms practices and strategies. Because many of these publications are written for teachers, it is critical that teachers have an accurate and working knowledge of the approach and are able to implement it skillfully in the classroom.

Section II

Number of Participants.

There will be three teachers and approximately 80 students participating in this study.

Population.

The population for this study is a group second grade teachers and the students in their classrooms. They were selected based on convenience, administrator desire to participate, and to find if differentiated instruction is improving mathematics achievement.

Exclusions/Inclusions.

Other second grade teachers, general education grade level teachers, special education, visual art, music, and physical education teachers will be excluded from this study. These three second grade teachers were included due to their interest and desire to improve differentiated instructional practices as well finding out if differentiated instruction actually improves student achievement as has been philosophically published in a variety of professional development resources. The students participating are pupils in these teachers' classrooms.

Section III

Participant recruitment.

Three teachers were approached by the researcher and the building administrator to participant. The researcher knows these three teachers of this school. Letters explaining the study and its importance as well as seeking written parent permission to participate will be sent with the students. Only students being given consent to participate will be a part of the student data.

Section IV

Methods and procedures to be used.

This will be a quasi-experimental study. Teachers will administer pretests to determine students' prior knowledge of four units of study. For the first two units, teachers will instruct as they normally would. Teachers will then experience twelve hours of training by the researcher on differentiated instruction before implementing the

final two units. Teachers will pretest again and then use the differentiated strategies learned from the training. A comparison will be made of the student growth of the first two units compared to the second two. Teachers will also administer a test three weeks after the second and fourth units as a means for determining retention of the materials in the two different instructional approaches. Teacher participants will also be observed for two 30-minute periods after treatment.

Section V

Data collection and storage.

A tally of the differentiated strategies used along with anecdotal notes will be taken of the observations. Pretest and posttest results will be compiled and organized. Students in each teacher's class will be randomly assigned a number. Each participant will be assigned a pseudonym. All electronically stored data will be kept in computer files that can only be accessed by password. In addition, notes will include no participants' names, only the assigned pseudonyms will be used. Students will be assigned a number without names of individual students being known to the researcher. Inteview notes will be shredded after recordings are made in the computer. The keys and passwords for all data and records will be accessible only by the researcher. In the research report, pseudonyms will be used to disguise the participants' names. The consent form includes a written description of the measures used to ensure participants' privacy is protected, and the researcher will explain these procedures prior to having the participant sign the consent form.

Section VI

Potential risks and discomforts.

Given the structure of this study, it is anticipated that there will be no physical, psychological, sociological or legal risks associated with participating in this study.

Potential benefits.

The benefits of the study will be a quantitative study of the effectiveness of differentiated instruction. Studies up to this point have been primarily of a qualitative or a limited mixed-methods design. This could be an impetus of a larger study for effectiveness in the field of education. In addition, there may be benefits to the researcher and building principal in that knowledge gained may be directly applicable to their work with teachers participating in a larger study in the future. This study will contribute to the knowledge base for further professional development needs and help teachers create a differentiated learning environment for students. This is especially important if the study proves that differentiated instruction improves student

achievement. Teachers may benefit through reflection by going through the observation and tallying processes.

Section VII

Incentives/inducements to participate.

There will be no incentives/inducements for participation.

Section VIII

Financial expense to the subject.

There will be no costs to be borne by participants.

Provisions for compensation for research-related injury.

Risk of physical injury is not expected.

Section IX

Additional materials submitted in separate documents to IRB.net

APPENDIX B

Dear Parents,

My name is Brian Scott, and I am a graduate student at Ball State University finishing my doctoral studies in elementary education. Ms. Jackson and three of the second grade teachers at Geist Elementary have agreed to help fulfill my last requirements by participating in my final doctoral study.

The name of the study is *The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom*. This is a quantitative study utilizing numeric data to see how this approach impacts student learning. Differentiated instruction is not a new idea. Grouping students for instruction, giving students choice in demonstrating their learning, and teachers using hands-on, visual, and auditory teaching techniques are examples of differentiated instruction. This study is important because this type of instruction has been growing in schools across America and the world (including Geist Elementary) over the last twenty years as a means of closing the achievement gap. While this type of instruction is thought to benefit student learning, there is very little research to support its use.

Attached is a consent form for your child to participate in the study. If you agree to allow your child to be a part of the study, please sign and date the bottom of the form and return to your child's teacher. Once the consent form is returned, a copy will be made and returned for your reference. Please remember that participation is voluntary, but as many student participants as possible will strengthen the results.

You can find more information on differentiated instruction at two of the following websites. There are others, but these do a good job of explaining the theory and practice.

http://www.differentiationcentral.com/

http://www.eht.k12.nj.us/~jonesj/differentiated%20instruction/1%20di%20homepage.htm

Thank you again,
Brian Scott

APPENDIX C

Introduction to the Study and Consent Form

Hello Parents:

I would like to invite your child to be a part of a study I am conducting to fulfill my dissertation requirement for my doctorate in elementary education. It includes the specific involvement of participants. Please read this document carefully, and let us know if you have any questions or concerns. My faculty contact at Ball State University is Associate Professor, Dr. Michael Putman. The chairperson overseeing my program is Associate Professor, Dr. Patricia Clark.

Thanks,

Brian Scott, Ed. S.

THE STUDY

The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom is a research study being conducted by Brian Scott, a doctoral student at Ball State University. The purpose of this study is to better understand if differentiated instructional strategies improve students mathematics acheivement. The following question will guide the study: *Does differentiated instruction impact the growth of student learning in the subject of math?*

PROCEDURE

As a participant in this study, the teacher will be asked to

- Participate in twelve hours of training of differentiated instruction theory, strategies, and planning for implementation.
- Teach two units of study after utilizing the assessment data to differentiate instruction lasting for approximately two hours each and be observed for two 30-minute periods using differentiated instructional techniques learned as result of the training.

As a student participant in this study, your child will

- participate during classroom instruction.
- have data collected from six particular assessments, InView aptitude results, and demographic information used in the study anonymously

BENEFITS

This study will contribute to the knowledge base for further professional development needs and help teachers create a differentiated learning environment for students. This is especially important if the study proves that differentiated instruction improves student achievement.

POSSIBLE RISKS

There are no foreseeable risks associated with participating in this study.

CONFIDENTIALITY

Each participant will be assigned a numeric code. All electronically stored data will be kept in computer files that can only be accessed by password. In addition, observation notes will include no participants' names. Once notes are recorded in the electronic database, handwritten notes will be shredded. The keys and passwords for all data and records will be accessible only by the researchers. All data will be confidential and no identifying information such as your name will be used in any publication or presentation of the data. At the end of the study the list of numeric codes will be destroyed. Transcripts identified by participant numeric code will be retained for continued analysis.

CONSENT TO PARTICIPATE

Your participation is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time without penalty. You may ask any questions of the investigator before signing the Informed Consent form and beginning the study, and at any time during the study.

For questions about your rights as a research subject, please contact Research Compliance, Sponsored Programs Office, Ball State University, Muncie, IN 47306, (765) 285-xxxx, irb@bsu.edu.

Researchers

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Consent

I, _____, give consent for my child, _____, to be a part of the research study. The research study is called, *"The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom."*

The study's goal has been told to me. I know what is going to happen. I will be able to ask questions if needed. My questions have been answered so far. I have read about the project. I wish to allow my child to be a part of it. I will get a copy of this form. It will be able to look at it later if needed.

_____ _____

Parent's Signature on Behalf of Student Participant Date

APPENDIX D

Introduction to the Study and Consent Form

Hello:

I would like to invite you to be a part of a study I am conducting to fulfill my dissertation requirement for my doctorate in elementary education. It also includes the specific involvement of participants. Please read this document carefully, and let us know if you have any questions or concerns. My faculty contact at Ball State University is Assistant Professor, Dr. Michael Putman. The chairperson overseeing my program is Associate Professor, Dr. Patricia Clark.

Thanks,
Brian Scott, Ed. S.

THE STUDY

The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom is a research study being conducted by Brian Scott, a doctoral student at Ball State University. The purpose of this study is to better understand if differentiated instructional strategies improve students mathematics acheivement. The following question will guide the study: *Does differentiated instruction influence the growth of student learning in the subject of math?*

PROCEDURE

As a participant in this study, you will be asked to

- Participate in twelve hours of training of differentiated instruction theory, strategies, and planning for implementation.
- Teach two units of study after utilizing the assessment data to differentiate instruction lasting for approximately two hours each and be observed for two 30-minute periods using differentiated instructional techniques learned as result of the training.

BENEFITS

This study will contribute to the knowledge base for further professional development needs and help teachers create a differentiated learning environment for students. This is especially important if the study proves that differentiated instruction improves student achievement.

POSSIBLE RISKS

There are no foreseeable risks associated with participating in this study.

CONFIDENTIALITY

Each participant will be assigned a pseudonym. All electronically stored data will be kept in computer files that can only be accessed by password. In addition, observation notes will include no participants' names. Once notes are recorded in the electronic database, handwritten notes will be shredded. The keys and passwords for all data and records will be accessible only by the researchers. All data will be confidential and no identifying information such as your name will be used in any publication or presentation of the data. At the end of the study the list of pseudonyms will be destroyed. Transcripts identified by participant pseudonym will be retained for continued analysis.

CONSENT TO PARTICIPATE

Your participation is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time without penalty. You may ask any questions of the investigator before signing the Informed Consent form and beginning the study, and at any time during the study.

For questions about your rights as a research subject, please contact Research Compliance, Sponsored Programs Office, Ball State University, Muncie, IN 47306, (765) 285-5070, irb@bsu.edu.

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Consent

I, _____, would like to be a part of the research study. The research study is called, *"The Effectiveness of Differentiated Instruction in the Elementary Mathematics Classroom."*

The study's goal has been told to me. I know what is going to happen. I will be able to ask questions if needed. My questions have been answered so far. I have read about the project. I wish to be a part of it. I will get a copy of this form. It will be able to look at it later if needed.

_____ _____

Participant's Signature Date

APPENDIX E

TIMELINE FOR STUDY

ACTION	TOPIC	DATE
Initial Meeting with Teachers and Principal	Review of the Study; Tentative Time Table	Jan. 25, Jan. 26, or Jan. 31 (before school at 8:00)
Unit Pretest	Chapter 12: Counting Money	One week before beginning unit
Unit Post test	Chapter 12: Counting Money	At conclusion of unit
Unit Pretest	Chapter 13: Using Money	One week before beginning unit
Unit Post test	Chapter 13: Using Money	At conclusion of unit
Cumulative Assessment	Chapters 12 and 13	Three weeks after Chapter 13 Posttest
Training in Differentiated Instruction		March 25 and 29
Unit Pretest	Chapter 25: Area	One week before beginning unit
Unit Post test	Chapter 25: Area	At conclusion of unit
Unit Pretest	Chapter 26: Fractions	One week before beginning unit
Unit Post test	Chapter 26: Fractions	At conclusion of unit: Week of May 2
Cumulative Assessment	Chapters 25 and 26	Week of May 23 (three weeks after Chapter 26 Posttest)

*Observations on two days during the differentiated unit implementations

APPENDIX F

Differentiated Instruction Observation Sheet

Teacher: SAMPLE

Observation Date: 2-23-11 Observation Time: 2:46-3:15

Strategy	Frequency	Duration
Anchoring Activities		
Compacting		
Independent Projects		
Interest Centers/Groups		
Tiered Assignments		
Flexible Grouping		
Learning Centers		
Varying Questions		
Mentorship		
Contracts		
Other		