School of Graduate Studies
Bemidji State University
1500 Birchmont Dr NE, #48
Bemidji, MN 56601-2699
218-755-2027

CAN THE DIFFERENTIATED MATH CLASSROOM BE A REALITY?

by

Carl Jeff Morris

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STATEMENT BY THE AUTHOR

Signed: _____

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APPROVAL BY RESEARCH PAPER ADVISOR

THIS RESEARCH PAPER HAS BEEN APPROVED ON THE DATE SHOWN BELOW:

_____ _____
Glen Richgels, Date
Committee Chair
Professor of Mathematics

_____ _____
Dean, College of Arts and Sciences Date

THE DIFFERENTIATED MATH CLASSROOM: MYTH OR REALITY?

Carl Jeff Morris

Imagine a math classroom that looked more like a Google workplace where collaboration, teamwork, and innovation are the centerpieces. Instead of just students sitting in rows passively learning about the nature of mathematics, picture a classroom of students in small circle discussing mathematics. This could range from groups working together on a problem solving strategy for a newly learned concept, students helping students using technology as an aid, another small group receiving intervention from the teacher, or individual students making or viewing instructional math videos. All of this according to research focused on classroom differentiation; specifically in middle school and high school math classrooms can be a reality. Differentiation among classrooms has become a popular topic in educational circles, but for math teachers has been a source of skepticism. Is it possible to build a math classroom around the philosophy of differentiated instruction? With continued hard work of math educators to provide the best math curriculum possible, concentrated teacher training, and focused implementation of new technologies that include smart devices such as iPads this pedagogy is very possible. This paper will explore the strategies and models of the differentiated math classroom and its functional reality.

Approved by:

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Committee Chair Date

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Committee Member

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Committee Member

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Graduate Faculty Representative

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Chapter 1: Introduction

Classroom differentiation is essential, but for clarification purposes, not the kind of differentiation that would have all the world's math minds completely engrossed. Instead, this paper explores an in-depth look at how the differentiated classroom functions today when surrounded by the challenges teachers face due to current affects impacting their students' diverse intellectual abilities. These affects include learning disabilities, IEPs, behavior disorders, mental health concerns, language barriers, different learning styles, socioeconomic differences, and limited professional development to properly train teachers. Add to this melting pot of educational challenges a world of technological advances that places information at the tips of everyone's fingers through super computers that anyone can carry in a backpack, purse, or pocket.

Among administrative teams and circles, the differentiated classroom seems to be the answer to all the performance gap issues teachers face. Yet many questions must be addressed. This paper's goal is to consider problems and solutions that have surfaced, specifically in math classrooms, from differentiated instruction and the tools and strategies used by math teachers across the United States. Can a classroom be effectively differentiated with 20 to 30 plus students assigned to one teacher? Does technology's evolution of tablets and hand-held devices aid in differentiation among students? Finally, what pitfalls do teachers face when trying to differentiate their classrooms? For example, are staff development dollars and time available, is the size of the gap between student ability within a classroom too large, and does the teacher have enough time outside of the teaching day to prepare differentiated instruction day in and day out?

To better understand the problem of whether or not math teachers can effectively and efficiently differentiate instruction for students on a consistent basis, a good definition of differentiation is needed. According to the book *Differentiation in Practice: A Resource Guide for Differentiating Curriculum*, differentiated instruction is a way to think about classroom instruction with dual goals. The dual goals that teachers must consider include both each student's learning needs and maximizing each student's learning capacity. The authors further define differentiated instruction as "a systematic approach to planning curriculum and instruction for academically diverse learners" (Tomlinson, Strickland & et al, 2005, p. 6). Teachers in general, and in math specifically, face varying student needs in which the traditional model of education becomes more and more outdated as our classrooms grow more diverse (Tomlinson, Strickland & et al, 2005, p. 6).

This diversity has drastically changed today's education system. In 2005 the U.S. Department of Education in their 26th Annual Report to Congress on The Individuals with Disabilities Education Act (IDEA) addressed the issues that diversity in classroom creates. In this report, statistics gathered revealed that 96% of general education teachers have students with learning disabilities (U.S. Department of Education, 2005). The report looked at a number of diversity factors including ethnicity, socioeconomic background (that specifically addressed poverty), and learning disabilities included under IDEA. When a teacher considers the whole spectrum of differences within a classroom along with class size and male to female ratios, there is definitely a case to be made for utilizing the differentiated classroom.

Statement of the Problem

In coming generations, education has a major task tackling students' diverse learning needs. Teachers must combine teaching theory; best practices strategies, classroom management, and a curriculum tailored to information available at the speed of light because technological advances now allow student's access to devices that, less than 20 years ago, were considered super computers. So how does a math teacher make it work in the day-to-day life of teaching and learning? Research done by the Cognition and Technology Group at Vanderbilt and cited in a recent article concludes the following:

> "Constructivist theories supporting cognitive processes emphasize students engaging in learning activities in which they are actively involved in the construction of their own knowledge through exploration, reasoning, and the application of problem solving strategies" (Serafino & Cicchelli, 2003, p. 80).

In a best practice report done by the Public Schools of North Carolina, other teaching theories advocate for differentiated instruction such as active learning where students are active in hands on learning experiences rather than passively receiving information. So if these are best practices for math instruction, is it realistic for math educators to teach a classroom of 20-30 students with different backgrounds, learning styles and even different exposures to technology? Can it be done effectively? If so, what tools make it possible? As Haager and Klingner (2005) write, traditional instruction means many teachers will be forced to teach to the middle (p. 19). The impact on our math classrooms across the country is that more students will continue to underachieve in mathematics and struggle to keep up. The brightest students will sit in classrooms, feel unchallenged, and, as a result, become bored with mathematics because of the traditional teaching methods'

limited ability to really take time offer learning experiences that maximize each student learning capacity and consider all the varying student needs.

Research Questions

1. What are the pedagogical methods a teacher might use to differentiate instruction to meet the needs of all students?
2. What are some of the specific strategies used in the differentiation of math instruction and curriculum?
3. Has technology played a role in differentiated instruction and, if so, how are teachers using one-to-one devices in schools to differentiate their classrooms?
4. Technology has led to the "Flipped Classroom" where teaching videos are created and assigned as work outside the classroom. Are Flipped Classrooms being used to differentiate math instruction?
5. Finally, are teachers being adequately given time to receive training and plan differentiated instruction?

Limitations

Some of the limitations that will surface in researching differentiated instruction involve the curriculum design of different school districts, not only in Minnesota, but also across the country. Due to different state demands on standards and testing, a school and/or district may design a scope and sequence of curriculum that may differ from another school or district. The limiting factor could be based on a school's decision to choose a more traditional math curriculum that lends itself more to traditional teaching versus a more reformed curriculum that incorporates group activities, individually paced

instructing, and self-exploration. Other limitations will be the specific diversities that math teachers must tackle within different classes. Each classroom has its own make-up, and depending on the location of the school or the class taught, its own group of students with differing ethnicities, socioeconomic backgrounds, learning disabilities, class sizes, and even male to female ratios. Much research focuses specifically on homogenous settings (grouped by ability) versus heterogeneous classrooms (mixed ability).

Delimitations

One of the delimitations of this paper involves the use of technology to differentiate instruction. This paper only considers the effect of one-to-one devices provided by the school. Another delimitation is the absence of comparison or contrast of specific curriculums designed for differentiation. This type of comparison often leads to a research on homogenous classrooms versus heterogeneous classrooms. This paper will not address the classroom where students are ability grouped (homogenous classroom), but rather it will address classes of mixed ability (heterogeneous classrooms), which are far more the common reality for high school math teachers in American middle and high schools. This paper will focus on the strategies and tools math teachers use to differentiate their curriculum and instruction. Finally, the research done in this paper will focus on the differentiated math classroom in middle and high school classrooms, leaving the study of such issues for elementary classrooms for others to explore.

Definition of Terms

- Differentiated instruction, according to Carol Ann Tomlinson, is the process of "ensuring that what a student learns, how he or she learns it, and how the student demonstrates what he or she has learned is a match for that student's readiness

level, interests, and preferred mode of learning" (Rock, Gregg, Ellis, & Gable, 2008, p. 32).

- One-to-one technology initiatives will refer to schools that have implemented either a laptop or tablet such as an iPad for each individual student used in daily classroom instruction.
- Traditional curriculum and reform curriculum will be used in this paper to distinguish between curricula that differ based on how they are presented to students. Traditional will refer to the method of teaching curriculum that relies heavily on teacher presentation, where as reform will refer to instruction that is shared between teacher and students.
- A heterogeneous classroom will refer to a classroom of students that have mixed ability.
- "Flipped Classroom" refers to an instructional approach wherein students watch videos of lessons created by teachers or students outside of class while working on problems or projects during classroom time with the teacher or other students.

Chapter 2: Review of Literature

Introduction

The literature review process for the topic of differentiated instruction in high school math classrooms revealed a very large spectrum of interpretation into what is meant by differentiated instruction means. Before addressing the specific questions of this research paper a clear understanding of the philosophies surrounding differentiated instruction must investigated. There are many professionals in education who have contributed a great deal to this topic, but there are some varying viewpoints. The present research will focus primarily on the definition and philosophy attributed to Carol Ann Tomlinson. In her book, *How to Differentiate Instruction in Mixed Ability Classrooms*, Tomlinson specifically highlights that while it is the differences of students that makes us individuals, it is the similarities of students that seem to take center stage in the classroom. Tomlinson (2001) goes on to describe differentiated instruction as, "shaking up what goes on in the classroom so students have multiple options for taking in information, making sense of ideas, and expressing what they learn" (p. 1). Tomlinson throughout several of her books paints a picture for educators for how differentiated instruction can be fused into classroom learning, and it is some of these philosophical descriptions that will serve as a foundation for answering the research questions related to differentiation among math classrooms in high school.

Differentiated instruction within the classroom is not individualized teaching or giving one-on-one instruction. It is instruction within a heterogeneous classroom where teachers focus to better understand *who we teach* and *what we teach* so that we become more flexible in *how we teach* (Tomlinson, Strickland & et al, 2005, p. 6). Differentiated

instruction demands that a teacher does not teach with one-size fits all mentality, which creates classrooms that teach to the middle of the class in terms of ability. Instead, differentiated instruction is more about creating an environment where students can have access to curriculum in multiple ways. It also allows for differing experiences that can place each student's needs at the center of the learning process to allow him or her to maximize learning (Tomlinson, Strickland & et al, 2005, p. 6). Instruction that is properly differentiated does not just focus on delivering content to a group, but positions and structures curriculum in such a way that it can be accessed by every student in the classroom regardless of the students' differences.

Changing from a classroom model where a teacher gives a lecture delivering content, asks students to take the same notes, then answers the same problem set, creates a classroom based on the assumption that all students process and understand information exactly the same. In addition, the teacher has also assumed he or she is working with a homogenous population where all learning abilities and other student factors are essentially the same (Gregory & Chapman, 2002, p. 4).

Teaching models like this lead to ability grouping and tracking programs such as gifted and talented programs and programs that serve students with low ability or learning disabilities. Research in the article *Curriculum Differentiation: multiple perspectives and developments in education* reports tracking has no overall effect on learning scores. In other words, students at a school where they are tracked or streamed according to ability do not outperform their counterparts in integrated (non-streamed) schools (Terwel, 2005, p.655). The author reports that one difference noted by tracking or inclusion is that high achieving students do seem to benefit in gifted programs, but even

more interesting is that low ability students seem to perform much better in heterogeneous classroom settings. Many other rationales contribute to ability grouping models. Genetics modeling is one example, where IQ, place students in a group. Another is described by or the author as tracking by social perspective, or "opportunity hoarding", where the elite and non-elite are placed in separate groups (Terwel, 2005, p.657-659).

Whether a school decides to track or not, it is unrealistic to believe that any group of students is completely homogenous when it comes to learning. The very heart of differentiated instruction is for teachers to be able observe and learn about each student within a classroom and provide learning experiences that accommodate not just for a select few, but for every student.

Strategies for Differentiated Instruction

Education has certainly changed in the United States over the past 50 years. The keeping up with the Joneses mentality has pushed our country's politicians to pass legislation that expects our students to be the best and brightest. Everything from the race to space, military strength, and technological advances, has made its presence felt in the classroom. So how does this impact the math classroom with differentiated instruction? The government has passed educational reforms over and over again, which directly affect the curriculum and standards that all teachers are responsible for.

In one recent qualitative study, students were reported to have positive outcomes in terms of level of engagement, motivation, and excitement about learning. The same article reported statistics about an elementary school's increase from 79% to 94% proficient after a switch from traditional, direct teaching to differentiated instruction. Also, a high school also was reported to have jumped from a 5.9 grade reading level to an

8.2 (Rock, Gregg, Ellis & Gable, 2008, p.34). So what methods and strategies successfully differentiate instruction specifically for a classroom of diverse learners?

The book *Differentiating Instructing in the Regular Classroom* defines differentiated instruction as rigorous, relevant, flexible, varied, and complex. Differentiation is presented as a two-step process. First, a teacher analyzes "the degree of challenge and variety in your current instructional plans." Next, the teacher modifies, adapts, or designs new approaches to instruction based on differing student needs, interests, and learning styles (Heacox, 2002, p.5-7). The table below is a portion of a checklist from *Differentiating Instructing in the Regular Classroom*. The book also includes practices for differentiating instruction and contrasts a traditional classroom with a differentiated classroom. The table clearly shows that traditional models put content at the center, while the differentiated classroom places individual student needs at the center (Heacox, 2002, p.19).

Classroom Practices Inventory

Use this inventory to look at what you are already doing in your classroom to differentiate instruction. Mark an "X" on each line to show where your current teaching practices lie on the continuum.

Traditional classroom:	*Differentiated classroom:*
Covering the curriculum is my first priority and directs my teaching.	I base my teaching on students' learning needs as well as on the curriculum.
Learning goals remain the same for all students.	Learning goals are adjusted for students based on their needs.
I emphasize mastery of content and skills.	I emphasize critical and creative thinking and the application of learning.
Students use the same informational resources (books, articles, Web sites).	I match students to specific informational resources based on their learning needs and abilities.

Figure 1: An inventory table on how you are doing differentiating instruction.

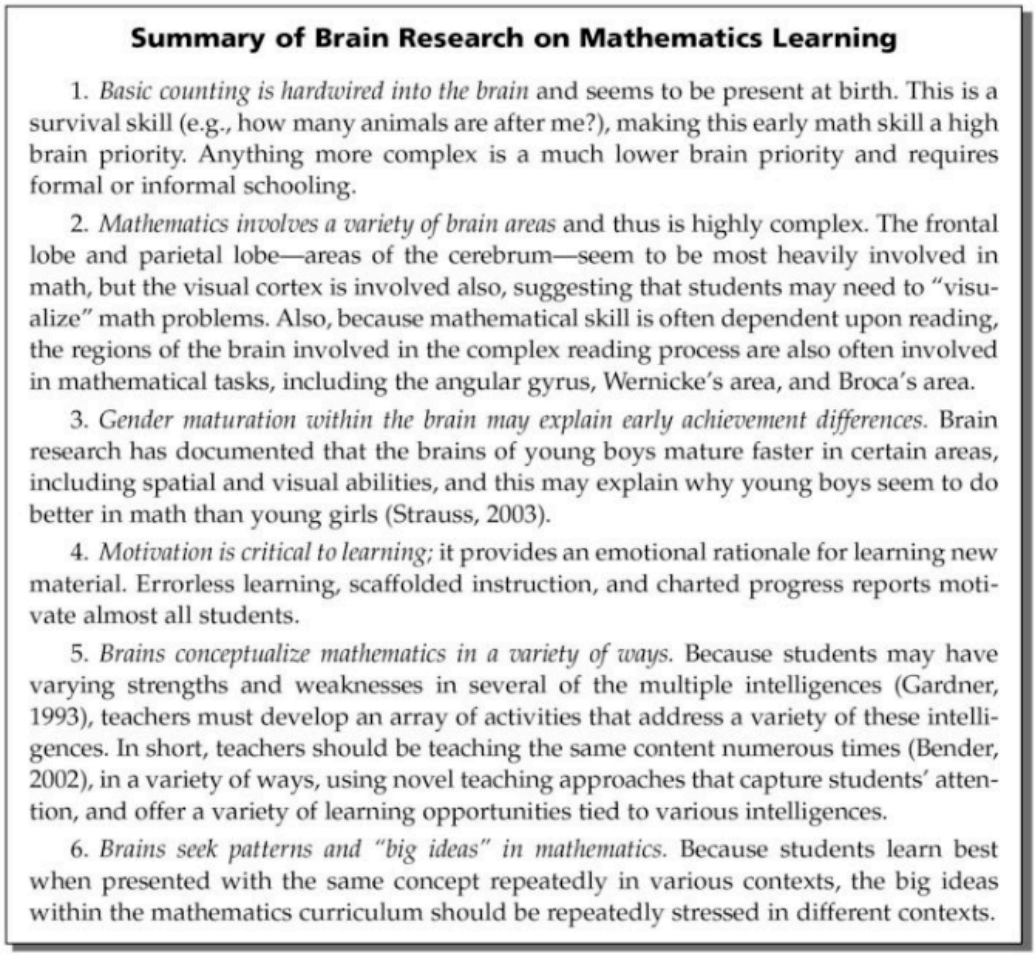
When discussing how to modify pedagogy to differentiate a classroom, five elements are often considered. These include content, process, products, affect, and learning environment. The content is what we teach and how we give access to students. For example, at one school, content may be given through a textbook or notes provided by the classroom teacher, while in another school, the content is given through an online activity the teacher developed. Process is how students come to understand the content or acquire skill. Products are the proof or demonstration of student knowledge. Affect refers to the connection made between thought and feeling; affect is internalizing what is learned. And lastly, the learning environment deals with the feel and function of the classroom. Learning environment could be everything from how a teacher sets up procedures for a lesson, or the arrangement of seats, to whether learning is done on your own or with others (Tomlinson, Strickland & et al, 2005, p.6).

The elements talked about so far deal with what teachers have direct control over. But what are the student characteristics that teachers must respond to when organizing curriculum and instruction? Tomlinson & Strickland mention three: readiness, interest, and learning profile. These go back to *who we teach,* whereas the first five mentioned deal with *what we teach*. Essentially, the *who we teach* characteristics deal with what the student's current knowledge is, what they like, and their preferred learning style. Therefore, teachers must structure their curriculum by considering the ability of every student, then get to know their students and what they like, and, finally, offer access to content in a variety of ways (Tomlinson, Strickland & et al, 2005, p.6).

Educators striving for classroom differentiation must not only consider these characteristics of what they teach and who they teach; they must also build a toolbox of

strategies that will support student success. When considering the methods for differentiating instruction, how students respond to the information teachers presented with becomes a priority.

Brain research has given teachers many leads into what strategies work best. The research shows that most complex thought processes involve multiple regions of the brain such as the frontal lobe and parietal lobe, which are responsible for higher order thinking skills (Sousa, 2001). Brain research reported by experts in *Differentiating Math Instruction* conclude that, since almost all higher level mathematics problems need to be visualized by the student, the visual cortex becomes highly involved (Bender, 2009, p.1-2). This same research shows that reading and math are learned differently as well. Mathematics requires multiple brain function because math demands multiple skill sets for mastery. For example, someone learning to read does not need to know how to solve a math equation; however, since mathematics involves reading numerals in word problems or math applications, students need to read in order to master math (Bender, 2009 p.4-7). A more in-depth understanding of the brain has given educators a great deal to think about when devising strategies for student learning. At the top of the next page is a summary of the brain research on mathematics learning from *Differentiating Math Instruction* (Bender, 2009, p.20).



Summary of Brain Research on Mathematics Learning

1. *Basic counting is hardwired into the brain* and seems to be present at birth. This is a survival skill (e.g., how many animals are after me?), making this early math skill a high brain priority. Anything more complex is a much lower brain priority and requires formal or informal schooling.

2. *Mathematics involves a variety of brain areas* and thus is highly complex. The frontal lobe and parietal lobe—areas of the cerebrum—seem to be most heavily involved in math, but the visual cortex is involved also, suggesting that students may need to "visualize" math problems. Also, because mathematical skill is often dependent upon reading, the regions of the brain involved in the complex reading process are also often involved in mathematical tasks, including the angular gyrus, Wernicke's area, and Broca's area.

3. *Gender maturation within the brain may explain early achievement differences.* Brain research has documented that the brains of young boys mature faster in certain areas, including spatial and visual abilities, and this may explain why young boys seem to do better in math than young girls (Strauss, 2003).

4. *Motivation is critical to learning;* it provides an emotional rationale for learning new material. Errorless learning, scaffolded instruction, and charted progress reports motivate almost all students.

5. *Brains conceptualize mathematics in a variety of ways.* Because students may have varying strengths and weaknesses in several of the multiple intelligences (Gardner, 1993), teachers must develop an array of activities that address a variety of these intelligences. In short, teachers should be teaching the same content numerous times (Bender, 2002), in a variety of ways, using novel teaching approaches that capture students' attention, and offer a variety of learning opportunities tied to various intelligences.

6. *Brains seek patterns and "big ideas" in mathematics.* Because students learn best when presented with the same concept repeatedly in various contexts, the big ideas within the mathematics curriculum should be repeatedly stressed in different contexts.

Figure 2: Summary of brain research on mathematical learning.

With the information revealed by brain research, educational researchers have been able to create strategies that seem to work best for student success. Well-researched strategies about differentiation fall into three specific categories, as detailed in *Differentiated Instructional Strategies*. The first category deals with creating the environment for the learner, which teachers do by setting objectives and providing feedback, positive reinforcement, and cooperative learning. The second is helping students develop understanding. Teachers can accomplish this through questions, cues, advanced organizers, note-taking, assigning homework, and non-linguistic representations. The final category is helping students extend and apply knowledge,

which could be done through identifying similarities and differences, or by generating and testing hypotheses (Gregory & Chapman, 2002).

Strategies for Differentiating Math Instruction

One of the biggest questions that must be answered is whether a math teacher can successfully differentiate instruction within a classroom of 20-30 students with large ability gaps? At times, it is quite understandable why some schools choose to group students by ability. However, in the article, "Teach in the Middle," the author argues that differentiated instruction is just "good teaching" (Wormeli, 2011, p.39-40). When President George W. Bush introduced No Child Left Behind (NCLB) in 2001, the policy's goal was to close the achievement gap. With the restructuring of the Elementary and Secondary Education Act (ESCA) of 1965, the focus of school became accountability and high standards, annual academic assessments, and consequences for schools that fail to educate disadvantaged students. No Child Left Behind led administrators' focus to ascertain that all students succeed.

The notion that teachers would not want all students to succeed is insulting to educators; especially the majority of the teachers who feel teaching is a mission or calling. However, for decades most teachers have subscribed to a bell-curve mentality of educating where teachers "teach, test, and hope for the best" (Gregory & Chapman, 2002). Teaching according to this traditional model, where direct instruction is the primary strategy, creates a classroom where student rely solely on the teacher for knowledge. In this setting where a single curriculum is taught to the entire class, students take very little initiative to learn on their own, and, instead depend completely on the teacher (George, 2005, p.190).

Across the country, legislation has led to more conformity to deliver and give students equal access to the same curriculum, regardless of ability. Now a teacher is confronted with the challenge of making sure no student falls behind, and most would agree that the philosophy behind NCLB is a very good for education. What most educators agree on is that the support and training to make this happen has not always been available. This issue will be addressed later. Research by Dr. R. L. Canady, of the University of Virginia shows there are three groups of students teachers must try to reach in classrooms:

> "A group of 25% to 37% of students learn 'in spite of us.' Those are the students who come ready, willing, and prepared to play the school game in order to succeed. These learners see education as a means to an end, do the work as assigned regardless of preferences, and have the support of significant others in their lives. A group of 15% to 25% of students is identified as having some exceptionality and receive additional resources. A large group of about 37% to 50% learn because of the teacher's skills and efforts and because of appropriate instruction and assessment aligned with CCSS (Common Core State Standards) targeted standards. Through differentiation, we give all these students the opportunity to learn to their full potential" (Gregory, Chapman, 2002, p. 5).

What about strategies for math differentiated instruction? Math teachers already feel the burden of covering the curriculum in time for the test, but can a teacher realistically meet the needs of each individual student in light of all that has been presented regarding differentiated instruction? Carol Ann Tomlinson has definitely positioned herself as the leading expert on differentiated instruction. The article,

"Creating a Differentiated Math Classroom", quotes Tomlinson's 2003 ASCD (formerly known as Association for School Curriculum and Development) Annual Conference address where she reminds educators that differentiation does not rely on this strategy or that one and goes on to say this type of teaching should offer students "a way up, not a way out" (Strong, Thomas, Perini, & Silver, 2004, p.78).

In the same article, mathematics is described as a "worse-case scenario for differentiation," but includes an outline of how to differentiate math instruction. Four areas of commitment for math teachers are outlined. First, in every unit, teachers are to include the four dimensions of mathematical learning – computation, explanation, application, and problem solving. Second, teachers are to help students learn their mathematical learning style – mastery, understanding, interpersonal, and self-expressive. Third, math teachers are to use multiple teaching strategies when exploring math concepts. According to the author, rotating strategies ensures that students with different learning styles are not limited in their process. Finally, teachers need to create and revise assessments to address the four dimensions of learning and the four different learning styles (Strong, Thomas, Perini, & Silver, 2004, p.78).

Other specific examples of classroom differentiation include readings materials or assignments at different levels of complexity, direct instruction in small groups, previewing and scaffolding, which allows teachers to provide assignments with assistance (Rock, Gregg, Ellis, & Gable, 2008). Another author presents ways to implement some of the following strategies to differentiate instruction, including centers, projects, choice boards, problem-based learning, and contracts (Gregory & Chapman, 2002).

Technology plus Classroom Differentiation

More then fifty years ago Sputnik zipped across the sky and, as NASA in 2008 so described it, "caught the world's attention and the American public off-guard" (Jolly, 2009). This sparked the government to pass the Nation Education Defense Act in 1958, which committed funds to education to promote STEM (Scientists, Technologists, Engineers, and Mathematicians) initiatives to focus our education on training young elite STEM workers (Jolly, 2009, p.50-51). In Thomas Freidman's book, *The World is Flat*, America was at a crossroads and "in order to remain viable and competitive in a growing global economy," led to initiatives like STEM. Combined with the legislations of NEDA and NCLB and according to an article published in the *New York Times* titled, "Math gains reported for U.S. students," the author Sam Dillon addresses how America is falling behind in mathematics and science. Another article referencing Dillon states the following:

> The latest Trends in International Mathematics and Science Study, or TIMSS, reports students making gains in mathematics but countries like Hong Kong, Taiwan, Russia, England, and Kazakhstan continue to outperform American students in mathematics and dominate in science. (Jolly, 2009, p.52)

With the infusion of the funding from these educational reforms, America's reaction to the "quiet crisis," and the technological advances due to the dawn of personal computing, handheld devices, and information at the speed of light, differentiated instruction takes on a whole new look in the classroom (Jolly, 2009, p.50).

What a math teacher deals with in a classroom when trying to differentiate math

instruction involves so much more than curriculum, because our learners arrive today as "digital experts". With the landscape of education changing constantly and our students' daily exposure to technology in classrooms across America, technology can be a vital part of the differentiated classroom (Gregory & Chapman, 2002). Author, Marc Prensky, describes students in his writing, *Teaching Digital Natives*; students want to use the tools of today (Gregory & Chapman, 2002).

In the last 10 years, educators have started one-to-one initiatives, which have led to so many new instructional strategies using today's technology to engage students in a fresh new way. One of these new strategies, coined the "Flipped Classroom," has caught on among educators due to the launch of Sal Khan's website Khan Academy (Khan). The article, "The Flipped Classroom," states the following:

> With teacher-created videos and interactive lessons, instruction that used to occur in class is now accessed at home, in advance of class. Class becomes the place to work through problems, advance concepts, and engage in collaborative learning. Most importantly, all aspects of instruction can be rethought to best maximize the scarcest learning resource—time. (Tucker, 2012, p.82)

It is not so much the teacher-made or even student-made videos that are so transformative, but what and how teachers integrate the videos into their instruction (Tucker, 2012, p.82-83). Other differentiated instructional strategies work well when integrated with technology that allow teachers provide access to content through a medium like an iPad. One work on technology and differentiation references six structures of technology that have prompted innovation in the use of certain differentiated instruction strategies. Below is a summary of those six descriptions from Benjamin's

book, *Differentiated Instruction Using Technology* described in an article by Julia Kara-Soteriou (Benjamin, 2005, p.5-6).

1) *Privacy* allow students who are behind to get support for content the rest of the class has mastered without feeling embarrassed.

2) *Collaboration and communication skills* focus on online technologies. These may include email, discussion boards, and access to curriculum through content management systems such as Moodle or Blackboard.

3) *Organization* refers to how students will document their own learning using tables, graphs, or some type of software or application.

4) *Learning styles and sensory learning* allows teachers to use technology to encourage visual, auditory, and social learning which helps meet those students needs teachers miss when solely using words, images, or sounds. Here an opportunity to draw upon individual student's experience and interests presents itself.

5) *Choices,* with the aid of the Internet, software technologies like apps on iPads'- offer many avenues for students to access information. The implications here are so great, because for perhaps the first time in history, educators can realistically allow students to be active participants in their own learning.

6) *Authentic learning* usually refers to project-based activities that, with the support of technologies in the classroom, take us beyond the days of paper-folding, cutting and coloring, or time-consuming data analysis and number crunching. Teachers can employ constructivist instruction to support authentic learning that allows students to collaborate and be creators of their own learning (Benjamin, 2005, p.5-6).

According to the data, consideration of the above six components allow a teacher

to use ~~a~~ strategies like Data Driven Instruction or the Flipped Classroom to meet specific student needs. Another example is how classroom response systems, known as clickers or apps that allow real time feedback, can aid teachers in to immediately adjust their instruction to address the needs of their student (Kara-Soteriou, 2009, p.86-90). With these new technologies, teachers are now seeing that differentiation as a transformative in their teaching, while also becoming a more viable model for classroom instruction especially in the mathematics.

Staff Development for Classroom Differentiation

By far one of the biggest hurdles of education is making sure teachers have the training and support to implement best practices and keep up with the ever changing landscape of education. It is very easy for a teacher to feel overwhelmed when trying to wrap his or her minds around classroom differentiation coupled with all the technology to learn to make it a reality. As this paper was intended to investigate, is the differentiated classroom a myth or a reality? Inadequate teacher training definitely stands in the way of making it a reality. In the 1990's teachers felt ill prepared to teach students with diverse learning needs (Rock, Gregg, Ellis, & Gable, 2008, p.34).

> "Although teachers express a desire to meet the needs of all their students, often excessive workload responsibilities, demands for substantial content coverage, and negative classroom behavior make the challenge seem insurmountable" (Rock, Gregg, Ellis, & Gable, 2008, p.34).

Now add technology to the above, and, as one author puts it, teachers end up being left behind. Technology completely changes our way of life, and younger

generations always seem to outrun the older when it comes to new technology (Benjamin, 2005, p.3-4). It is not that young people learn any better, but because technology is something they know. Essentially students and teachers work from different frames of reference. Teachers have to be willing to catch up with students or learn from them and embrace the world they have grown up in or what teachers teach will be irrelevant to the world they inherit (Benjamin, 2005, p.3-4).

According to Tomlinson, when specifically addressing staff development, notes that teachers feel very inadequate and lack confidence when thinking about differentiated instruction. It is possible that the one size fits all model for staff development does not allow time for teachers to focus on the strategies necessary for differentiated instruction. Tomlinson identifies four barriers teachers encounter in staff development (Tomlinson, 2005, p.11), including the following:

> …"lack of reflection on students as individuals; lack of clarity about what students should know, understand, and be able to do as the result of a segment of learning; inadequate repertoires of instructional approaches that invite student-centeredness and flexibility; and lack of skills to manage and facilitate flexible instruction" (Brighton, Hertberg, Moon, Tomlinson, & Callahan, in press).

According to studies, differentiation is certainly going to become more and more important to teacher instruction as American students grow more diverse – which is happening all the time racially, ethnically, economically, and socially (Tomlinson, 2005, p.9). Also, according to the U.S. Department of Education (2001), in most districts now 96% of teachers have students with an identified learning disability in their classrooms (Tomlinson, 2005, p.9).

Richard DeFour and Robert Eakers are quoted as stating; “The most promising strategy for sustained, substantive school improvement is developing the ability of school personnel to function as professional learning communities.” This philosophy might be what is needed to overcome the hurdles Tomlinson mentions that schools face in training their teachers (Tomlinson, 2005, p.9).

Chapter 3: Interpretations

Considering the recent research about differentiated instruction, it is reasonable to ask if the research is convincing enough to mandate a major shift in our classrooms across America, especially in the area of mathematics. Or, is this new education buzz-phrase just an unrealistic idea that administrative types can throw around at meetings and suggest that teachers now should do business in this way with their students? This paper set out to answer some of the major questions surrounding this fairly new teaching philosophy. The dynamics of the American classroom certainly have changed over the last half a century, but if one were to take the teaching styles of math classrooms in either the 1950's or 1960's and compare them to today, there probably wouldn't be too much of a difference. Middle and high school math teachers still rely heavily on direct instruction that involves extensive lecture, some teacher led examples, and a problem set assigned to all students with the same expectations for all. Because students have relied so much on teachers for their learning, this model of direct instruction leaves little opportunity for student creativity or input into the way they learn. By far, the biggest changes in the classroom setting involve our students and advances in technology. Unfortunately, today's math classrooms have not done a good job of adapting to these changes.

One of the first questions this paper researched was the different methods of teaching that center around differentiated instruction. After clearly presenting what differentiation is and is not, it seems that if education in America is about how to best educate all students, regardless of individual differences, then this type of instruction is not only best for students, it is also a change needed in our shifting educational climate. What is clear from the research is that classroom differentiation puts student needs at the

forefront of what teachers do and is arguably best for all students. Teachers who differentiate their instruction have focused their teaching philosophies on using all tools possible to create environments that promote creativity, collaboration, and a healthy exchange between learners and teachers. This philosophy then becomes a method that goes beyond just presenting content: differentiation compels teachers to deliver information in a way that encourages students to interact with the content through a learning style that makes the subject matter more relevant. Classrooms that focus on this kind of instruction give students a chance to progress from simply consuming and memorizing content to becoming creators of their own learning experience, and, ultimately, being able to relate to the world. Essentially, a classroom that differentiates instruction forces teachers to adopt a coaching role that examines each individual student's needs and allows each student to focus on using his or her own strengths.

Some math educators have tried to present an insurmountable pedagogical wall where content can only be delivered to students in the same way and at the same rate. Classroom differentiation opens up opportunities to bridge disconnects between how learners perceive and think about math and how math instruction is conveyed. For example, consider students in a classroom scenario. A teacher might have a group of math students who learn best with direct instruction, before progressing to problem sets that focus on repetition. Eventually, after lots of practice, they hopefully observe the nature of the mathematics. In another group, students may learn best by starting with a problem and then trying to solve it with cues from the instructor. This allows students to take an active role in how they learn a particular math concept, and allows them to draw upon previous experience to help understand the math. After learning the concept, the

students may be able to leverage the new experience to look at similar math problems. Then the teacher may ask them to practice a few problems. Ultimately, classroom differentiation is a method of instruction by means of which either type of learner may flourish. It allows for individual instruction within a large group where student needs are considered a priority.

Classroom differentiation is a major shift in how we view education in the math classroom. Teachers today may feel that students must learn math the same way we did thirty, forty, or fifty years ago. However, so much has changed in the world around us. How we interact with, deal with, use, and receive information is much different than fifty years ago. Someone looking up a simple math formula fifty years ago might have been forced to go to a library and consult a reference book. Today we can just pull out a smart phone and Google the question and access its answer. Another example could be writing a program for a business. Years ago this was done solely by a consultant or by someone a person hired. But today, with access to certain technologies, one can develop his or her own application or program. In education, where many technologies are math driven and supported, it only makes sense to give students experiences that use today's technologies together with the experiences associated with how we interact with information. Conrad Wolfram, founder of Wolfram Research Europe and a prominent proponent of Computer-Based Math – a reform of mathematics education to use more information technology, was quoted in an interview by Daniel Arayra of *HPC Wire* as stating the following:

> "Clearly technology introduces new modalities of learning for all subjects — be they video, interactivity or geographical independence. Though it's only just begun, individualized learning that enables students to discover at their own pace

> and at least to some extent set their own learning paths is clearly crucial too. But here's why math is different. Unlike say, the subject of history, math outside education has fundamentally changed over the last decades because computers have liberated it from what's typically the limiting step of hand calculating. We live in a far more mathematical world than we did precisely because math is based on computers doing the calculating. But in education that transformation hasn't happened yet. Around the world almost all students learn traditional hand-calculating, not computer-based math. Sometimes it's "computer-assisted," that is, applying some of the new modalities to the traditional subject. That's holding them and their countries back from more creative, conceptual math. Indeed, a larger and larger chasm is opening up between math for the real world and math in education. Technology isn't an optional extra for math, it's fundamental to the mainstream subject of today" (Araya, 2012).

Conrad Wolfram has done numerous conferences, including a *TedTalk*, about the need for reform in math education. Classroom differentiation can be part of the solution as long as math teachers are given the support and training, not only with the content they teach, but also with the different technological mediums being used in today's world.

With all the research and other evidence that supports the differentiated classroom, many teachers are really starting to see the necessity for a different way to teach across their classes' diverse spectrum. This paper shows that not only are those strategies realistic for the math-teacher, but that strategies developed by professional educators are broad enough to assure that teachers don't have to be satisfied with reaching only the middle of the class. With the aid of such strategies, teachers using

differentiated instruction can challenge the brightest students and keep them interested and engaged. Teachers can continue to move to the middle as well, and with collaboration and creativity, also reach the lower end of the continuum regardless of the students' needs or disadvantages.

Sometimes it may be hard to imagine a math classroom where students learn at different paces, with some students receiving direct instruction, while others work on problem-solving activities. What worries most math educators is the enormous task of managing a differentiated classroom. The research reveals that this type of classroom does not transform teaching into individual tutoring sessions between the instructor and student: rather, it becomes a classroom where the learning is shared among all students and the teacher. When designing curriculum to maximize learning experiences, teachers keep in mind that both content and student needs are valued and considered. In addition, with the differentiated philosophy the teacher's work also focuses on the continual adjustment of learning goals that emphasize critical and creative thinking, plus the application of learning (Heacox, 2002, p.1-3). Implementation of the right strategies to address student needs, along with collaborations through which students share the learning and teaching, give the teachers opportunities to reproduce instructional experiences among students. This model gives ownership to the individuals in the classroom not only for their own learning but also for the education of their peers. The consequence of this ownership is that students feel accountable and create an atmosphere that breeds teamwork.

Can schools really make this a reality in their math classrooms? Can math education embrace the future, or will we continue to hold on to teaching methods that

were relevant for previous generations? Today's math education does not always meet the demands of the real world, which many times leaves students feeling as if they will never use what they learn. Technology has definitely impacted our culture and education and is finally starting to really make its way into math classrooms. In the 1980's, classrooms started putting computers in the classroom, but access was a factor. Since then, computers have come a long way, and now we have handheld devices that would have been considered super-computers twenty years ago. Not only has the hardware made tremendous advances, but the software and applications that can now be used within education has changed how people interact with information. This is especially true in mathematics. With access to these technologies, math teachers can allow students to explore a mathematical concept in a variety of ways. For those students who previously craved visual explanations, teachers can create learning experiences on a hand-held device by using specific applications that focus on modeling mathematics. Schools across the country are implementing one-to-one initiatives, either with personal computers or with tablets (like iPads) for all students. For math classrooms, these programs really give teachers an opportunity to use a medium that can address varying student needs. If math teachers are able to employ different strategies to differentiate instruction and incorporate technology, then the management of this teaching model may be sensible.

The biggest difficulty in math education today seems to be this: how can one teacher successfully teach a curriculum to 20-30 students who differ not only in abilities, but also differ with respect to many other factors that affect each student? One such factor is the amount of support a given student might receive at home, due perhaps to the

household's socioeconomic status. This could play a large role in the success of the student. Or consider this: one student may be from a family that values education much higher than another student's family and works with their child consistently during the school year. A student that comes from such a family may also be afforded more opportunities in education than students who come from homes that don't consider education to have much value. A teacher may also have students who go home to a lack of support of another sort, because their parents are not English speaking.

When taking into account all these difference among students, it seems unrealistic to assume that all students would learn content the same way and at the same pace. However, because mastery of one concept often depends completely upon mastery of another, math teachers for years would simply present the same content to all students at the same time. This type of teaching does not account for these difference mentioned, but again assumes a homogenous setting. Research involving the brain shows that how students perceive and think about math varies from individual to individual, so the reality is that learning can vary significantly from student to student. Therefore, with twenty to thirty students, a teacher may have a few who are ready to move on immediately after instruction, whereas another group may need to work a little longer, and yet another group may be stuck because it lacks a previous skill.

The differentiation of curriculum, combined with the technology of the flipped classroom, allows teachers to duplicate themselves, in a sense. Flipped Classrooms use short instructional videos similar to typical direct instruction, but the videos can be accessed and watched by students at multiple and different times. This approach allows students who struggle with a concept to go back and watch the instruction over and over,

while other students could move on. This gives teachers the opportunity to implement strategies during class that focus more on creativity, problem solving, and application: as a result, more class time can be spent bringing students a greater depth of understanding.

According to the research, all of these results hinge on whether or not math teachers possess the confidence to transform their classrooms. Most math teachers' learning experiences greatly influence their teaching, and the way they learned math when they were in school is typically what teachers will revert to in their own classrooms. So, in order to transform math classrooms of today, instructors are going to have to understand how students of today learn. To make this a reality, teachers will need the time to develop and practice specific learning strategies necessary for classroom differentiation, and schools must commit time and money to train their teachers. Math teachers also must do their part and look beyond the classroom to see how math is being used today. They also must devote time to understanding the students they teach. The more they know about each student's strengths and weakness, the more targeted teachers can be when providing learning experiences for all students.

Finally, probably the most frightening hurdle teachers face deals with using the latest technologies. Teachers often feel that their abilities to navigate modern technology are extremely inadequate. The learning curve gets steeper and steeper each time there is an upgrade or an update. By the time teachers finally learn how to enter grades on the new classroom management piece the school bought, the software company comes in and updates the program. No matter how hard teachers work to stay ahead of the technology, students just seem to update right along with the latest software. This can intimidate teachers and make them hesitate to use the latest devices that promote classroom

differentiation.

What this paper reveals is that differentiation can be a reality in the math classroom. However, for math teachers to make this work, they need to try to understand math, and the learning of math, through their students' eyes, because this type of approach to teaching is exactly what differentiated instruction is about. A final quote by Carol Ann Tomlinson describes differentiated instruction in this manner. "Differentiation is simply a teacher attending to the learning needs of a particular student or small groups of students, rather than teaching a class as though all individuals in it were basically alike."

Chapter 4: Conclusion

Most of the time, a conclusion should bring one to an end or at least a sense of closure, but I find that after proposing my questions, researching this topic, and finding some answers, I am brought to a new beginning. When I used to think about how one might differentiate curriculum, the idea seemed somewhat overwhelming. How does a teacher clone himself or herself so each individual student has his or her own personal version of the teacher for individualized instruction?

At Perham High School, I have been a part of implementing a one-to-one iPad initiative. During this time, a goal was to make the content I delivered in my classroom available in different forms to students. With Moodle, a content management system, and iPads, I have been able to take the curriculum I teach and make it completely digital. At first, I thought using the iPads and a few useful math apps would create a differentiated classroom. What I discovered through my own experience and this paper's research is that giving every student an iPad and teaching math with a new medium does not necessarily transform a classroom. Essentially, I took the curriculum I taught and transferred it from paper to an iPad, and I required my students to do the same.

One of my best experiences this year that resembles classroom differentiation was my use of the philosophy of a Flipped Classroom. With iPads in every student's hand, I was able to incorporate a very important strategy of classroom differentiation, which allowed students to become creators in the learning experience. I would assign a student a problem and expected the student to learn how to solve the problem and explain the process to the class. The student had to work out the problem with the correct steps and the correct solution. Then, with the use of an app called *Educreations,* students made an

instructional tutorial explaining the problem. Then they would post the video to my *Moodle* page on a Wiki for all the students to access and view. Before the students could create their video, they had to collaborate with me via email to make sure their solution and explanation was accurate. To further collaborate, we used an iPad app called *Notability*, which allows students to use a stylus to write and work out problems. The collaborative process was extremely rewarding for me as a teacher because, for the first time in my teaching, I was getting to discuss one-on-one with every single student any problems he or she was having in understanding a concept.

Recently I had a great opportunity to take the collaboration between my students and me even further by having students use a collaborative website called *Blendspace*. In this particular assignment, I asked each student to write a problem that required he or she to graph a piecewise function. After creating the problem, they had to collaborate back and forth with me before they could create their own instructional video. After they created the video, they were instructed to place it online into the *Blendspace*, a website that acts as a portfolio of student work. After all the videos were placed into the website, the students could now watch any video made by any student in the classroom and even comment on each others' problems. As a result, an open collaboration now exists among the entire class.

At this point, I asked students to watch any ten of the thirty plus videos created to prepare for the next day's quiz on piecewise functions. This quiz was created by randomly choosing problems from the videos the students had created. Students responded very positively to the experience and were excited to see whose problems actually showed up on the assessment.

So often as teachers, we present curriculum and assume our presentation was so well done and complete it would be impossible for anyone to not understand. What I realized is that some of the presentations I saw from the students' work on the iPads would never occurred to me if I had been teaching in front of the whole group. This experience allowed me to understand more deeply the way the students perceived the instruction, and, furthermore, it gave me clues into the ways students learned the content.

One other important part of classroom differentiation that has surfaced through this research is the importance of assessment. Appropriate assessment at the right time and the various strategies used to differentiate instruction gives a plethora of information about the learner and whether or not the current strategy provides good instruction. This also allows teachers to determine if content is being learned. In my experience with classroom differentiation, proper and timely assessment has become extremely valuable. Whether it is a Pre-test and Post-test or a common formative assessment used throughout the year, the information gained from these assessments provides valuable insight into one's learners.

Perham's motto for our iPad initiative, named Project iEngage, is to provide transformative and transparent curriculum. This is exactly what differentiated instruction fosters among classrooms. Before writing this paper, I thought differentiation was a myth; it was impossible to imagine myself getting to the needs of every student, every day. Now, I not only believe it can be a reality, I believe it is a necessary reality for math teachers everywhere. This is a change that is desperately needed in our math education. Classroom differentiation offers teachers opportunities to embrace the world our students live in and to leverage their realities to meet the needs of our diverse student populations.

Today, we can offer our students choices when it comes to the ways they learn. Instead of assuming all children learn best by sitting through a 30-minutes lecture taking notes and watching a math instructor work out problems and then try to duplicate this homework by completing the odd-numbered problems 1-59, we can transform our classrooms through differentiation.

Imagine a math classroom that looks more like the workplace of Google, where groups of students work together in teams on problems, while other students work with the teacher on mastery of a previous concept, and other students investigate a new problem posed in the next section of the curriculum. As the name of our Perham initiative, Project iEngage, suggests, classroom differentiation is about engaging students. Our curriculum needs to be accessible to all students, and classroom differentiation is a way that teachers can make this happen. Through this teaching approach and the use of technologies like iPads, I personally see my classroom being transformed into a place where diverse learning styles and needs can be targeted. Therefore, I am convinced that differentiation can be accomplished and is the key to the type of reform our math classrooms need, and I know firsthand that differentiation can provide and sustain rigorous and relevant content essential for student success.

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