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THE IMPACT OF INTERNALLY DESIGNED MATHEMATICS DIFFERENTIATION SYSTEM ON GIFTED AND TALENTED 5^{TH} AND 6^{TH} GRADE STUDENTS

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THE IMPACT OF INTERNALLY DESIGNED MATHEMATICS DIFFERENTIATION SYSTEM ON GIFTED AND TALENTED 5TH AND 6TH GRADE STUDENTS

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ABSTRACT

THE IMPACT OF INTERNALLY DESIGNED MATHEMATICS DIFFERENTIATION SYSTEM ON GIFTED AND TALENTED 5TH AND 6TH GRADE STUDENTS

Mathematical talent development in middle school is significantly impacted by students' access to academic learning opportunities that include collaborative learning with similar ability peers and match student's interests and level of ability instead of age and grade-level. Access to and participation in domain-specific gifted programs for mathematically talented students has a significant impact on the level of their future talent development, their social-emotional well-being, and opportunities later in life. The purpose of this mixed-methods non-experimental action research study was to explore the impact an internally designed mathematics differentiation system (provided in a multiple days per week pull-out format by school's gifted and talented educator) had on gifted and talented 5th and 6th grade students in a public school in Nashville, Tennessee. The study explored how participation in this program affected 25 gifted and talented 5th and 6th grade public school students feeling of joy (social-emotional aspect) in class; feeling challenged (productive struggle); perseverance (ability to complete complex tasks), and achievement (grades, achievement ratings). The data was collected through student questionnaires, teacher observations, and de-identified student data from student records and classwork.

Key words: gifted education, mathematically gifted, middle school students, gifted services

I dedicate this to gifted children: being different, being lonely sometimes, being gifted – always.

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I wish I could go back in time and tell all my teachers that I carried the best of their teaching to my classroom, or at least tried to and will continue trying. Their kindness, creativity, and experience continue to touch my students through me.

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Introduction

Although research shows that gifted students benefit from domain-specific services that match their areas of gifts and interests, many public-school districts' gifted services mostly target the entire grade-level of gifted learners with a non-domain specific 1-2 hours of weekly pull-out. This practice creates a unique problem for mathematically gifted 5th and 6th grade students. Although mathematically gifted 7th and 8th grade students often have access to high school credit math classes, mathematically gifted 5th and 6th grade students require services that cannot be fully addressed through differentiation in a regular classroom, honors classroom, or by an immediate placement into high school level courses. Additionally, daily differentiation is an individual choice of classroom teachers and not a mandate. Absence of domain specific gifted services, lack of an educational mandate for gifted differentiation, teachers' lack of training, classroom time pressures, and resources to accommodate advanced 5th and 6th grade math students create an environment of high frustration among advanced students and their parents about the lack of challenge in these grades, and some advanced math students are lost to private and magnet schools that can meet their academic needs. Loss of students to private and magnet schools reduces the proportion of advanced math students in public school classrooms and makes grouping advanced students together yet more challenging in a self-replicating cycle. This problem is not as acute in 7th and 8th grades since students have the option to enroll in high school credit math classes.

Gifted students' areas of strengths are their biggest areas of need (Roberts et al., 2018). Providing students with an opportunity to develop their mathematical talents based on their level of ability instead of age and grade-level leads to acceleration in development of mathematical ability (Stanley & Benbow, 1982) -- an access to a special intellectual "habitat"—an opportunity to spend considerable time in the talent field (Bloom & Sosniak,1991), a feeling of well-being that is connected in gifted children to an opportunity to develop mastery in the domain of their talent (Winner, 2003), and affects psychological well-being of gifted students (Cross, 2014). This study is focused on researching the impact of an internally designed mathematics differentiation system on gifted and talented 5^{th} and 6^{th} grade students. The main question is: What is the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students? The sub-questions are: How are students impacted in regard to joy (social-emotional aspect), feeling challenged (productive struggle), perseverance (ability to complete complex tasks), and achievement (grades in math and percentage of successfully completed tasks)?

Literature Review

Current research in gifted education strongly supports domain-specific services for gifted and talented students that match their areas of giftedness and interest, explicitly stating that gifted students' areas of strength are their biggest areas of need (Roberts et al., 2018) and that access to curriculum that matches gifted and talented students' intellectual ability is closely connected to their social and emotional wellbeing. Although many middle schools offer high school credit mathematics to 7th and 8th grade students, these classes are not an option for most gifted 5th and 6th grade students. How can middle school gifted programs best support gifted and talented 5th and 6th grade students in mathematics? What is the best research-supported curriculum for such programs? What impact does access to and participation in such programs have on gifted students' academic achievement, development of mathematical reasoning skills, and their social and emotional wellbeing? Current literature on developing mathematical talent in middle school can be divided into four distinct categories: a) general theoretical framework of mathematical talent development that includes middle school (identification and educational services), b) developing mathematical talent in middle school: theory and practical applications, c) impact of access to and participation in gifted programs on mathematically talented students, d) evaluating gifted programs at schools for their effectiveness.

Developing Mathematical Talent

Conversation on the best way to support mathematical talent development must start with how giftedness is viewed in modern education. Subotnik et al. (2001) outlined two distinct positions: a) gifted students have distinct ability traits that separate them from non-gifted in a qualitatively different way (Roeper, 1996), and b) "with very few exceptions, children are born capable of learning anything" (Mighton, 2003); giftedness does not exist, and outstanding achievement can be open to anyone given appropriate opportunities and practice. While per Subotnik et al. (2001), data does not fully support either position, variations of both views are present within the school system among teachers and administration and extend tremendous influence on how mathematically gifted students receive services.

Going forward, for the purpose of this research, giftedness in mathematics will be assumed as a combination of an intensity, persistence, and ability that needs access to opportunity and motivation. This view is supported by the majority of current research into gifted education (Assouline & Lupkowski-Shoplik, 2011), and theoretical frameworks by Renzulli and Gagne, highlighted by National Association for Gifted Children (NAGC): clear differentiation between outstanding natural abilities, the gifts, and systematically developed high-level competencies, the talents (Gagne, 2015), and above average ability, task commitment, and creativity (Renzulli, 1978).

Although not every domain of academics can be addressed by school-based programming, mathematics is the one that naturally lends itself to advanced learning for K-12 as the whole curriculum is already available. However, moving advanced learners through curriculum at a pace and depth different from other learners remains a challenge that US public school systems meet at dramatically different levels. Per Assouline and Lupkowski-Shoplik (2005), developing math talent includes a necessary sequence of events and conditions: a) early recognition and identification through assessment and testing, b) advocacy on behalf of students by both parents and teachers, and c) access to curricula, programming, and resources specific to mathematically gifted students. The challenges of developing mathematical talent within the public school system are due to the wide range of mathematical ability to be accommodated. While some students can be served through enrichment and classroom differentiation, others require radical acceleration to meet the level of their talent's needs. The key to developing a mathematical talent in K-12 is finding an "optimal match" between the student's abilities and achievements and the "appropriate level and pace of the mathematical curriculum" (Assouline & Lupkowski-Shoplik, 2005, p. 173). Assouline and Lupkowski-Shoplik (2005) outline five steps to the "optimal match": 1) assessing academic abilities and achievements, 2) determining general grade-level of curricula for further testing (often through above grade testing), 3) providing curriculum-based assessment from the actual curriculum student's school is using, 4) matching to the appropriate level of curricula for the instruction, and 5) regularly reassessing for progress, satisfaction, and frustration.

Once the appropriate opportunity for the mathematically gifted student is provided, fully utilizing that opportunity, and possessing a healthy motivation for learning (Subotnik et al, 2011) are vital for further talent development. Renzulli (1978) named task commitment one of the cornerstones of being gifted, saying that together, task commitment, creativity and above-average ability represent the Three Ring Conception of Giftedness. Rambo-Hernandez (2016) has detailed explanations on what opportunity and motivation represent as critical parts of mathematical talent development:

- Opportunity consists of acceleration, collaboration, and competition. Mathematically gifted students require acceleration based on their academic needs, not their age, and should be foundational for mathematical talent development, not optional. Acceleration has the most research support as the method for mathematical talent development. Collaboration and competition are presented as students working independently and collaboratively in solving complex problems while grouped for instruction in schools, in summer camps, math circles, and competitions.
- Motivation is seen as a specific approach to mathematics, a possession of a growth mindset and an understanding that developing mathematical talent requires considerable effort. In fact, Rambo-Hernandez (2016) breaks down motivation into three components: need for considerable effort from the student, being comfortable and learning from mistakes, and the role of adults in normalizing the amount of effort it takes to become exceptional in mathematics, understanding the critical role making mistakes plays in learning, and adopting mastery orientation towards learning -- developing, not displaying competence.

In 1982, Stanley and Benbow wrote “Educating Mathematically Precocious Youths: Twelve Policy Recommendations.” In it, they outlined the importance of early identification, taking courses aligned to students’ ability and achievement level regardless of age; substituting college courses for high school courses, including part-time concurrent high school and college enrollment; taking AP classes and exams; full-time college enrollment before high school diploma is earned; lowering the age restriction to the National Science Foundation (NSF); accelerating NSF summer institutes; providing more scholarships and fellowships for academically advanced scholars; conducting research on female mathematical reasoning ability; teaching gifted children on how to study effectively; and researching the reasons for and ways to counteract frequent hostility in the American society toward precocious intellectual achievement. These recommendations came out from the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University, a result of decades of work with thousands of mathematically gifted students who were mostly identified as gifted at the age of twelve in seventh grade. Stanley and Benbow (1982) gave special importance to acceleration in development of mathematical ability, saying that "boredom kills interest, appreciation for the subjects, and sharpness of thinking" and that "eager accelerated youths will go further educationally, in more difficult fields and at the most demanding universities, than if they were left at age-in- grade" (Stanley & Benbow, 1982, p. 8) stressing the opportunity for accelerated youth to complete their graduate degrees in their teens and twenties instead of thirties, adding to peak productive mental and physical years.

VanTassel-Baska (1994) stressed that creating content modifications to meet the needs of gifted learners had to match with appropriate instructional strategies. Citing current research into the talent development of mathematically gifted youth, Johnsen and Ryser (2016) laid out eleven differentiation strategies for Common Core Standards in Mathematics to meet the talent development pace and academic needs of K-12 students gifted in mathematics:

1) Accelerating standards and clusters of standards across grade levels and courses (Colangelo et al., 2004).
2) Varying the pace within learning activities (Johnsen, 2015).
3) Building complex problems (Saul et al., 2010).
4) Encouraging creativity by developing open-ended problems (Sheffield, 2006).
5) Adding depth (Kaplan, 2009).
6) Making connections and integrating math across domains (Kaplan, 2009; VanTassel-Baska, 2004).
7) Identifying themes or concepts within and across domains (VanTassel-Baska, 2004).
8) Using questioning to encourage higher level thinking and mathematical processes (Johnsen & Sheffield, 2013; Sheffield, 2013).
9) Solving problems that relate to global issues (Partnership for 21st Century Skills, n.d.).
10) Engaging students in problems of interest to them (Gavin et al., 2009).
11) Involving students in extracurricular activities (Barbeau & Taylor, 2009).

Domain talent development, including the domain of mathematics, requires creation of focused areas of study via flexible schedules and credit acquisition (Kettler, 2016). Elite talent development with a goal to future eminence, should include prioritizing work in talent areas and minimizing distraction in other areas (Kettler). Kettler advises gifted high school students to focus on AP credit acquisition, college credit classes, other academically advanced classes, research, and extracurricular academic activities to their areas of interest to place themselves into the trajectory of elite talent development in that area.

Lubinski and Benbow (2006) in the Study of Mathematically Precocious Youth (SMPY) after 35 years of longitudinal research concluded that it is important to tailor educational opportunities to each student's ability, and a vital precursor for discovering student's ability is the use of above-level assessments followed by differential opportunities, clarifying that growing talent includes personal readiness and environmental opportunity, further stressing that psychology could not afford to neglect individuality that was found within intellectually talented populations. Additionally, analyzing achievements of top math-science graduate students, Lubinski and Benbow (2006) revealed several important similarities among them: participation in advanced math-science learning opportunities and special programs, excelling in these programs, commitment to studying and research.

Rambo-Hernandez (2016), named opportunity and motivation as two key levers to unlocking mathematical potential. Additionally, Rambo-Hernandez (2016), analyzing the data in Lubinski and Benbow's study (2006), emphasized that ability also has a critical role to play in the development of mathematical talent. She unequivocally stated that level of ability mattered, and that the needs of the top 1% of developing mathematical talent cannot be met with a one-size fits all approach (Rambo-Hernandez, 2016).

Before summing up the key ingredients to mathematical talent development from the above sources, it is important to mention one more key component to successful development of mathematical talent discovered by Uri Treisman in the 1970s by observing the study habits of his math students at Berkeley and confirmed by multiple studies since then (Fullilove & Treisman, 1990; Treisman, 1992). When students formed study groups outside of the classroom, worked collaboratively on hard problems, and combined their academic and social lives through study groups, it turned math students into more effective learners who saved time analyzing and catching each other's mistakes, built upon, and benefitted from individual differences, and improved class grades.

As a concluding perspective of the research into the development of mathematical talent, a concise list of key components becomes evident: early discovery, individually tailored opportunities, mentorship, effective studying skills, personal commitment to work and research, and combining academic and social lives through study groups.

Developing Mathematical Talent in Middle School

Developing mathematical talent in middle school falls into two categories: theory -- what is recommended and backed by years of research (Assouline & Lupkowski-Shoplik, 2005; Sheffield et al., 2010; Lupkowski-Shoplik, 2010; Assouline et al., 2015; Greens at al., 2010; VanTassel-Baska & Stambaugh, 2005; Rusczyk, 2010; Reis & Coach, 2000; Winner, 2003), and practical application -- what is available at schools gifted individuals attend due to staffing, resources, and individual beliefs held by teachers and administrators.

Recommendations backed by the National Council of Mathematics and multiple researchers (Sheffield et al., 2010) have multiple paths for best addressing development of mathematical talent in middle schools. One of them, the Pyramid of Educational Options (Assouline & Lupkowski-Shoplik, 2005), has multiple scenarios of advanced placement through acceleration and enrichment based on the middle school student's level of mathematical ability:

Exceptional mathematical talent

- Early college entrance
- Resting out of college course
- Whole grade acceleration

- Taking high school classes while in middle school, AP classes earlier than 11th grade, college courses while still in high school
- At least 2 years of acceleration in mathematics
- Fast-paced summer classes or distance-learning classes similar to or offered by university-based talent researchers
- Individually paced instruction based on diagnostic testing
- Mentorship

High talent

- Early course entry such as Algebra 1 in 6th or 7th grade, AP Calculus AB in 11th grade
- Telescoping curriculum (completing two years of math in one)
- Honor-level classes

Moderate Talent

- High-ability grouping
- Participation in contests and competitions
- Academic counseling and educational planning

Suggested program models for middle school mathematical talent development, predominantly recommend a combination of acceleration and enrichment that matches students' abilities, needs, and interests, emphasizing that one-size-fits-all approach does not work for mathematically gifted students (Lupkowski-Shoplik, 2010). However, while research has supported individually tailored acceleration for years (Assouline et al., 2015), it is the least implemented and the hardest to put in place path to mathematical talent development in middle schools. It is especially challenging for 5th and 6th grade students mostly due to what VanTassel-Baska and Stambaugh (2005) see as lack of subject matter knowledge and classroom management skills, issues with teachers' attitudes and beliefs about learning, lack of time and knowledge on how to modify the curriculum, “issues regarding responding to diverse populations, difficulties of effective use and location of resources, lack of planning time, lack of administrative support, and lack of relevant pedagogical skills” (VanTassel-Baska & Stambaugh, (2005, p. 211).

One of the critical components of developing mathematical talent in middle school is availability of teachers specially trained to serve the gifted populations (Greens at al., 2010), the kind of teachers who can recognize talent, understand the needs of individual students, and provide instruction tailored to gifted populations. Because in addition to an individually-tailored acceleration and enrichment, mathematically gifted individuals require a curriculum that is more articulated, challenging, and rigorous (Gavin & Sheffield, 2010) that is delivered by teachers with expert content knowledge in mathematics, especially in reasoning and problem solving, as well as training to understand cognitive, emotional, and behavioral development of middle school gifted populations (Greens et al.).

In practice, many schools choose grade-level in-classroom differentiation and enrichment instead of more radical forms of acceleration. Curriculum matched to student age instead of ability and only adjusted for depth with added enrichment has significant educational pitfalls (Assouline & Lupkowski-Shoplik, 2005): even when perfectly executed by a teacher with ample planning time, professional training, and resources, it at most will serve moderately talented math students whose needs can be met with ability grouping and differentiated materials; it will not meet the needs of high and exceptional mathematical talent students; gifted students may feel resentful of having to complete extra work. Students with high and exceptional ability in mathematics cannot receive appropriate differentiation in 5th grade math when they are ready for

Algebra 1. Analyzing the program models for mathematically gifted in middle school, Lupkowski-Shoplik (2010) described once-a-week pull-out services for gifted students as a program that recognizes students' mathematical ability, groups them with other like-ability peers, and provides more challenging curriculum to study, but has significant drawbacks: such services are not guaranteed to be domain specific, and even if they are, the common downside is that students still have to return to a grade-level instruction in math on a daily basis and have to make up the work they missed while receiving gifted services, even if the work is below their ability level.

So, while there is ample research-backed data for what is best for mathematically gifted middle schoolers, in practice, there is often a lack of opportunity, resources, will, and domain-trained professionals. To provide a fully balanced opportunity for mathematically gifted students in middle school, it would require a change of policy on identification, acceleration and grouping (Stambaugh & Benbow, 2010), matching programs to abilities, needs, and interests (Lupkowski-Shoplik, 2010), curriculum tailored to the needs of gifted learners (Gavin & Sheffield, 2010), a cohort of teachers who are experts in the domain of mathematics and gifted education (Greens at al., 2010), and a wide range of extracurricular opportunities in mathematics (Rusczyk, 2010).

Impact of access to and participation in gifted programs on mathematically talented students

While there are voices in education and society today that call gifted programs elitist, giving advantage to a select group of mostly middle and upper-middle class students, and advocate for dismantling all gifted public school programs, especially in mathematics, there is significant data showing that access to ability and need appropriate challenging curriculum is not only essential to mathematical talent development, but also necessary for social-emotional well-being of gifted students, as well as one of best ways to prevent underachievement among gifted.

Cross (2014) calls absence of appropriate educational opportunities for gifted students an educational malnourishment, saying that it affects psychological well-being of gifted students by imposing feelings of fatigue, disinterest, and underachievement through boredom; leads to underdevelopment of talent, at a high cost to both an individual and a society at large; begets problems with self-concept, increases self-doubt, and causes reduction in agency. Access to or lack of environment where the microsystem and mesosystem (Bronfenbrenner, 1979) are filled with challenging and ability appropriate mathematics learning environments either creates or fails to set up a special intellectual "habitat" needed to promote and nurture three phases of the development of talent (Bloom & Sosniak, 1991): 1) opportunity to spend considerable time in the talent field -- ability matched classes, enrichment, competitions, clubs, and other outside of school opportunities to grow math talent; 2) exposure to subsequent talent fields and the skills required to excel -- students cannot learn what they already know or what does not match their need for depth and complexity; 3) introduction to talent community modeling of highest standards in pursuit of excellence -- exposure to mentors in the fields of mathematics, teachers with deep advanced content knowledge, history of mathematics and access to advanced resources.

Gifted students without appropriate access to ability/need based resources tend to fall into three categories of underachievement (Reis & Coach, 2000): imposed -- never acquire knowledge due to lack of access to advanced opportunities; value system -- do not put effort into class they do not find valuable or challenging; environmental -- gifted students tend to stand out in a regular classroom, and sometimes choose to underachieve to hide their ability or/and to stay socially accepted by their peer circle.

Considering that development of eminence or high achievement in the domain of talent is strongly connected to training and hard work (Bloom, 1985), and hard work is necessary to transfer giftedness into expertise (Winner, 2003), schools play a critical role as a gateway to programs that challenge gifted children and put them on the path from talent to expertise in their domain. In gifted children, a feeling of well-being is connected to an opportunity to develop mastery in the domain of their talent (Winner). Additionally, Winner writes that even though "moderately gifted children (in whatever domain) are socially and emotionally well adjusted, this is not true of gifted children with more extreme levels of ability" (Winner, 2003, p. 376). She goes on to say that profoundly intellectually gifted children account for a higher-than-average rate of social and emotional problems (Hollingworth, 1942; Janos & Robinson, 1985), mainly because they are "out of step with their peers," (Winner, 2003, p. 376), underchallenged and bored at school, and need more contact with peers like themselves. Otherwise, reduction in well-being leads to underachievement, negative attitudes towards school, and potential dropping out.

Evaluating Gifted Programs

Gifted programs need to be evaluated to check for evidence that they are serving the needs of gifted and talented children. Multiple studies researching effectiveness of specific gifted programs have four unifying qualities:

1) concentrate on measuring the outcomes for the participants without an in-depth evaluation of the curricula (Lubinski & Benbow, 2006; Jones, 2011; Boazman & Sayer, 2011)

2) focus on evaluating/suggesting curricula components based on prior research (Stanley & Benbow, 1982)

3) measure the effectiveness of unique local programs tailored to the domains and levels of giftedness of its participants and available resources (Weinberg et al., 2011),

4) include middle school gifted programs as a component or do not include them at all (Hsu et al., 2008; Wai & Allen, 2019; Mulkey et al, 2005; Adelson et al, 2011; Jones, 2011)

VanTassel-Baska (2019) calls for internal and external evaluations to check for evidence of growth in students receiving the services, document program development methods that work, and check for the adherence and usage of national program standards. As a basic due diligence, VanTassel-Baska suggests annual internal evaluations to check for stakeholders' perceptions, product, and portfolio accomplishments, judge the instruments and processes used to identify and assess the gifted students, assessment of above grade-level outcomes, and fidelity of the curriculum implementation. Furthermore, VanTassel-Baska suggests external evaluations to be held every three to five years and used to evaluate the extent to which gifted programs are dynamic and progressive, to validate the models employed to serve the gifted (grouping models, acceleration options, counseling approaches), programs' effectiveness for meeting the NAGC standards, and to address political problems of operating gifted programs.

According to VanTassel-Baska (1992), effective curriculum for gifted learners should have a correspondence between gifted learner characteristics and curricula, include multidimensional assessment process, be piloted in the classroom and reviewed by teachers and students; matched to learner outcomes, used for continuous curricular planning, have an evaluation built in, be used to assess student progress and future needs, and be implemented by staff trained in gifted education and knowledgeable in the content area they are teaching.

Conclusion

After division of research and literature on developing mathematical talent in middle school into four categories of a) general theoretical framework of mathematical talent development that includes middle school (identification and educational services), b) developing mathematical talent in middle school: theory and practical applications, c) impact of access to and participation in gifted programs on mathematically talented students, d) evaluating gifted programs at schools for their effectiveness, the following conclusion could be reached:

1. General theoretical framework of mathematical talent development suggests that learning opportunities must match student's level of ability instead of age and grade-level; and should include collaborative learning opportunities with like-ability peers and provide an option for in and out of school enrichment, mentorship, and competition.
2. Development of mathematical talent in middle school is significantly impacted by student's access to academic learning opportunities in school, and while research is clear on what is best for mathematically gifted middle schoolers, in practice, there is a lack of opportunity, resources, will, domain-trained professionals, and programs matched to students' abilities, needs, and interests.
3. Access to and participation in gifted programs on mathematically talented students are not a luxury and have a significant impact on their social-emotional well-being, mental health, degree of talent development, and opportunities later in life.
4. External and internal evaluations of gifted programs should be ongoing at schools for student growth, documentation of effective program development methods, adherence to and usage of national program standards (NAGC), and student outcomes beyond grade level and K-12 education.

The Internally Designed Mathematics Differentiation System was created by the gifted and talented middle school educator based on the research above and in response to a local school's need for advanced mathematics services for 5th and 6th grade gifted students, a need expressed by students, teachers, parents, and the principal. This study was designed to research the impact of *The Internally Designed Mathematics Differentiation System* on gifted and talented 5th and 6th grade students (MNPS district's only domain specific math pull-out program for gifted students*)*.

Methods

The purpose of this mixed methods non-experimental action research study (Leech et al., 2011) was to research the impact an internally designed mathematics differentiation system has on gifted and talented 5th and 6th grade students' feeling of joy (social-emotional aspect) in class, feeling challenged (productive struggle), perseverance (ability to complete complex tasks), and achievement (grades, achievement ratings). The study follows the logic of mixed methods by relying on both qualitative and quantitative methods of data collection (Leech et al.). The reliance on the qualitative methods in creating and choosing the instruments of the study allowed to optimize the gathering and the interpretation of the data (Leech et al.); using quantitative methods provided more clarity for forming data clusters and precise application of descriptive statistics. The process of mixing of the qualitative and the quantitative approaches within the study broadens the consequent interpretation of the data allowed to optimize interpretation of data (Leech et al.) from the perspective of wide-ranging realities in gifted education, implications in the current gifted education research, the study's findings, and serving the immediate academic and social-emotional needs of study participants. Research Question(s): This study was guided by the following research questions:

Main question: What is the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students? Sub questions: How are students impacted in regard to 1) joy (social-emotional aspect), 2) feeling challenged (productive struggle), 3) perseverance (ability to complete complex tasks), 4) and achievement (grades in math and percentage of successfully completed tasks).

Context and Participants

Originally, there were 29 potential study participants, but one student left the school, one student changed a program, and two students did not want to participate in a study. Out of 27 students, 25 gave their assent after consent was received from their parents: twelve 6th grade and thirteen 5th grade students. Participants were 5th and 6th grade students from a public school in one of Tennessee's urban districts who have been identified as eligible for gifted and talented services and chosen to receive a pull-out math service vs. ELA or STEM gifted services. Students attended GATE (Gifted and Talented Education) Math class 4-5 times per week: 3-4 times for about 45 minutes during school's PLT (Personalized Learning Time) and one time per week for 50 minutes during Related Arts time.

The two groups of students were comprised of the following: Group 1 (13 students): the 5th grade group had 13 male students (11 white students, 1 student identified as two or more races, one student identified as American Indian or Alaska Native). Group 2 (12 students): the 6th grade group had 1 white female student and 12 male students (11 white students, one student identified as two or more races).

Both groups included only students identified by the district as gifted and talented through multiple measures and eligible for gifted and talented services. There was one twice-exceptional student present in the 6th grade group. Twice exceptional-education students were defined as those who have a disability and were identified eligible for both special education and gifted and talented services by school (Roberts et al., 2018).

Internally Designed Mathematics Differentiation System for Gifted and Talented 5th and 6th Grade Students (Appendix F) was created by the researcher based on research into mathematical talent development, gifted education, and many conversations with teachers, parents, students, and the school's principal who expressed the need for this type of program. Additionally, the program is based on National Association of Gifted Children's (NAGC) PreK-12 Gifted Programming Standards (NAGC, 2019); aligned with National Council of Teachers of Mathematics (NCTM) Process Standards (NTCM, 2000); aligned with Common Core state standards for mathematics adapted for gifted and advanced learners (Johnsen & Sheffield, 2013) and approved by Metro Nashville Public Schools (MNPS) Office of Gifted and Talented Education.

Internally Designed Mathematics Differentiation System's Instructional Goals

1. *Provide opportunity for acceleration, collaboration, competition, and creativity*
    a. Accelerate standards and clusters of standards across grade levels and across courses.
    b. Vary the pace within learning activities.
    c. Encourage creativity by developing open-ended problems.
    d. Make connections and integrate math across domains.
    e. Identify themes and concepts within and across domains.
    f. Solve problems that relate to global issues.
2. *Provide motivation to exert effort, get comfortable and learn from mistakes*
    - Build complex problems
    - Adopt mastery orientation towards learning
    - Use deliberate questioning techniques to elevate thinking

- Normalize the amount of effort it takes to be exceptional in mathematics
- Provide safe place to make mistakes
- Normalize being comfortable with mistakes and seeing them as a learning opportunity
- Encourage developing persistence as a vital quality of a mathematician

Learning Goals

a. History of mathematics. By watching excerpts from "The Story of Maths," through classroom discussions, collaborative, and individual work, examine the development of key mathematical ideas throughout the history of mankind and learn how mathematical ideas contributed to the world's science, technology, and culture.
b. Learn about connections between history of science and mathematics and individuals who contributed to the development of both.
c. Strengthen mathematical reasoning (primarily focus on algebraic reasoning), critical thinking, and computational skills through solving puzzles, cognitive tasks, challenging logic, and mathematical problems.
d. Students follow individual learning paths in Stanford University developed software RedBird Math

Content and Pacing Note

Curriculum was constantly adjusted to serve the needs of individual students; accelerated or slowed down as needed; materials added to better serve students' strengths and interests, as students worked to meet their learning and instructional goals.

Data Sources and Collection

The data was collected through student surveys during class, teacher observations during class, de-identified student data from student records, and classwork.

Data Source 1

A twenty-question survey was administered with students to better understand the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students' feeling of joy (social-emotional aspect) and engagement in class. It took approximately ten minutes to complete the *Engagement Versus Disaffection with Learning: Student Report* (Skinner et. al., 2008; Appendix A), which was completed and collected in the researcher's classroom. Students were given printed copies of a survey at the end of the class, instructed on how to complete it, and had opportunity to ask clarifying questions.

Data Source 2

A ten-question survey was administered to students to better understand the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students' feeling challenged (productive struggle) and perseverance (ability to complete complex tasks) in class. It took approximately ten minutes to complete *the Student Classroom Work Rating Scale* (Appendix B); it was completed and collected in the researcher's classroom. Students received printed copies of the survey at the end of the class, instructed on how to complete it and had opportunity to ask clarifying questions. *Student Classroom Work Rating Scale* was created based on The National Council of Teachers of Mathematics (NCTM) Process Standards, taking into consideration Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013), NAGC Pre-K-Grade 12 Gifted Programming Standards, and adapted into Student Classroom Work Rating Scale questions for gifted and talented 5-6th grade math students.

Data Source 3

A classroom observation was administered once-a-week for four concurrent weeks by the teacher during students' collaborative group work to better understand the level of engagement. It took approximately 30 minutes to complete *the Teacher's Student Observation Scales* (Appendix C) each time, which was conducted in the researcher's classroom concurrently with daily observations of students working in groups and providing feedback, as the teacher already followed similar Teacher's Student Observation technique for internal classroom pedagogical purposes to track student engagement. Teacher rated students as an observer using Direct Observation.

Data Source 4

De-identified student data, *Achievement Chart* (Appendix D), was collected from student records and classwork by the teacher to better understand students' level of achievement using grades in a regular math class, math software RedBird Math (REDBIRD Mathematics, 2022) achievement rankings, and percentage of correctly completed, and percentage of attempted classwork for the duration of the study.

Data Source 5

A single question survey, 5-point *Level of Difficulty Likert Scale to Measure Challenge,* measuring students' feeling of being challenged (productive struggle) in class. It took approximately 1-2 minutes to complete 5-point *Level of Difficulty Likert Scale to Measure Challenge* (Appendix E), which was collected in the researcher's classroom on paper. Students were given printed copies of a single question survey attached to each task they completed in class for the total of twenty tasks with instructions on how to complete it and with the teacher available to answer questions.

Data Analysis

The researcher collected the data from student questionnaires (surveys), teacher/researcher's own observations, de-identified student data from student records, and classwork. The overall data from each question were combined into tables and analyzed using descriptive statistics.

Results

Out of 27 potential student participants, 25 (93%) gave their assent after consent was received from their parents: twelve 6th grade and thirteen 5th grade students. 100% of 25 students completed every survey. Data for all 25 students are present fully in all the data sources.

Data Source 1

A twenty-question survey, the *Engagement Versus Disaffection with Learning: Student Report* (Skinner et. al., 2008; Appendix A), was given to students to better understand the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students' feeling of joy (social-emotional aspect) and engagement in class. Descriptive statistics data from the survey is provided in Tables 1 and 2. Data from questions 2, 3, 5, 7, 9, 13, 15 measuring student joy and social-emotional well-being in class was placed into Table 1, and data from questions 1, 4, 6, 8, 10, 11, 12, 14, 16, 17, 18, 19, 20 measuring student engagement in class was placed into Table 2. Data for Tables 1 and 2 was collected using a 4-point Likert scale measuring likelihood (Not at all true; Not very true; Sort of true; Very True) and collapsed into dichotomous scales: Not true (Not at all true; Not very true) and True (Sort of true; Very True).

Table 1

Engagement Versus Disaffection with Learning: 5th and 6th grade Student Report: Questions 2, 3, 5, 7, 9, 13, 15 measuring joy and social-emotional well-being in class

	4-point Likert scale								Collapsed dichotomous scales			
	Not at all true		Not very true		Sort of true		Very true		Not true		True	
	n	%	n	%	n	%	n	%	n	%	n	%
Q2	1	4%	2	8%	11	44%	11	44%	3	12%	22	88%
Q3	12	48%	10	40%	3	12%	0	0%	22	88%	3	12%
Q5	3	12%	0	0%	13	52%	9	36%	3	12%	22	88%
Q7	16	64%	4	16%	3	12%	2	8%	20	80%	5	20%
Q9	17	68%	4	16%	3	12%	1	4%	21	84%	4	16%
Q13	10	40%	10	40%	2	8%	3	12%	20	80%	5	20%
Q15	1	4%	2	8%	11	44%	11	44%	3	12%	22	88%

Results from Table 1

For Question 2, *I enjoy learning new things in class,* 1 student answered -- Not at all true, 2 students -- Not very true, 11 students -- Sort of true, 11 students – Very true. Collapsed into dichotomous scales: 3 (12%) students – Not true, 22 (88%) students – True.

For Question 3, *When we work on something in class, I feel discouraged,* 12 students answered -- Not at all true, 10 students -- Not very true, 3 students -- Sort of true, 0 students – Very true. Collapsed into dichotomous scales: 22 (88%) students – Not true, 3 (12%) students – True.

For Question 5, *Class is fun,* 3 students answered -- Not at all true, 0 students -- Not very true, 13 students -- Sort of true, 9 students – Very true. Collapsed into dichotomous scales: 3 (12%) students – Not true, 22 (88%) students – True.

For Question 7, *When I am in class, I feel bad,* 16 students answered -- Not at all true, 4 students -- Not very true, 3 students -- Sort of true, 2 students – Very true. Collapsed into dichotomous scales: 20 (12%) students – Not true, 5 (88%) students – True.

For Question 9, *When I'm in class, I feel worried,* 17 students answered -- Not at all true, 4 students -- Not very true, 3 students -- Sort of true, 1 student – Very true. Collapsed into dichotomous scales: 21 (84%) students – Not true, 4 (16%) students – True.

For Question 13, *Class is not at all fun for me,* 10 students answered -- Not at all true, 10 students -- Not very true, 2 students -- Sort of true, 3 student – Very true. Collapsed into dichotomous scales: 20 (80%) students – Not true, 5 (20%) students – True.

For Question 15, *When I'm in class, I feel good,* 1 student answered -- Not at all true, 2 students -- Not very true, 11 students -- Sort of true, 11 student – Very true. Collapsed into dichotomous scales: 3 (12%) students – Not true, 22 (88%) students – True.

Questions 2, 5, 15 were positively worded for joy and social-emotional well-being in class: enjoying learning new things in class (question 2), thought class was fun (question 5), and felt good in class (question 15). After collapsing data for these questions into dichotomous scales (True; Not True), *Cluster 1* emerged: 22 students (88%) enjoyed learning new things in class, thought class was fun, and felt good in class.

Negatively-worded questions 3, 7, 9 asking students if they felt discouraged (question 3), bad (question 7), or worried (question 9) yielded similar data once reverse coded: 20 – 22 (80 – 88%) students denied feeling bad, worried, and discouraged, and 3-5 students (20 – 12%) agreeing to a various degree that they felt either discouraged, bad, or worried. Out of 5 students who marked feeling bad in class, 3 marked the answer *Sort of true* for both question 7, *When I am in class, I feel bad,* and question 15*, When I'm in class, I feel good,* either acknowledging both feelings happening during class, or having answers cancelling each other out due to students not carefully reading the questions.

Only 2 students out of 25 answered that they feel bad in class (question 7) and denied feeling good in class (question 15). The same two students answered true to trying hard to do well in school (question 1) and the gifted math class (question 6), listening carefully (question 8), getting involved (question 10), participating in discussions (question 17), and paying attention (question 20). One of these 2 students said that he enjoys learning new things in class (question 2); both denied being interested in classroom work (question 12).

Table 2

Engagement Versus Disaffection with Learning: 5th and 6th grade Student Report: Questions 1, 4, 6, 8, 10, 11, 12, 14, 16, 17, 18, 19, 20 measuring student engagement in class

	4-point Likert scale								Collapsed dichotomous scales			
	Not at all true		Not very true		Sort of true		Very true		Not true		True	
	n	%	n	%	n	%	n	%	n	%	n	%
Q1	1	4%	0	0%	6	24%	18	72%	1	4%	24	96%
Q4	8	32%	12	48%	2	8%	3	12%	20	80%	5	20%
Q6	1	4%	0	0%	6	24%	18	72%	1	4%	24	96%
Q8	1	4%	1	4%	6	24%	17	68%	2	8%	23	92%
Q10	1	4%	1	4%	10	40%	13	52%	2	8%	23	92%
Q11	3	12%	13	52%	6	24%	3	12%	16	64%	9	36%
Q12	3	12%	2	8%	8	32%	12	48%	5	20%	20	80%
Q14	18	72%	4	16%	1	4%	2	8%	22	88%	3	12%
Q16	5	20%	8	32%	8	32%	4	16%	13	52%	12	48%
Q17	0	0%	2	8%	9	36%	14	56%	2	8%	23	92%
Q18	9	36%	8	32%	5	20%	3	12%	17	68%	8	32%
Q19	19	76%	5	20%	0	0%	1	4%	24	96%	1	4%
Q20	1	4%	0	0%	7	28%	17	68%	1	4%	24	96%

Results from Table 2

For Question 1, *I try hard to do well in school,* 1 student answered -- Not at all true, 0 students -- Not very true, 6 students -- Sort of true, 18 students – Very true. Collapsed into dichotomous scales: 1 (4%) student – Not true, 24 (96%) students – True.

For Question 4, *In class, I do just enough to get by,* 8 students answered -- Not at all true, 12 students -- Not very true, 2 students -- Sort of true, 3 students – Very true. Collapsed into dichotomous scales: 20 (80%) students – Not true, 5 (20%) students – True.

For Question 6*, In class, I work as hard as I can,* 1 student answered -- Not at all true, 0 students -- Not very true, 6 students -- Sort of true, 18 students – Very true. Collapsed into dichotomous scales: 1 (4 %) student – Not true, 24 (96%) students – True.

For Question 8, *When I am in class, I listen very carefully*, 1 student answered -- Not at all true, 1 student -- Not very true, 6 students -- Sort of true, 17 students – Very true. Collapsed into dichotomous scales: 2 (8%) students – Not true, 23 (92%) students – True.

For Question 10, *When we work on something in class, I get involved*, 1 student answered -- Not at all true, 1 student -- Not very true, 10 students -- Sort of true, 13 students – Very true. Collapsed into dichotomous scales: 2 (8%) students – Not true, 23 (92%) students – True.

For Question 11, *When I'm in class, I think about other things*, 3 students answered -- Not at all true, 13 students -- Not very true, 6 students -- Sort of true, 3 students – Very true. Collapsed into dichotomous scales: 16 (64%) students – Not true, 9 (36%) students – True.

For Question 12, *When we work on something in class, I feel interested*, 3 students answered -- Not at all true, 2 students -- Not very true, 8 students -- Sort of true, 12 students – Very true. Collapsed into dichotomous scales: 5 (20%) student – Not true, 20 (80%) students – True.

For Question 14, *When I'm in class, I just act like I'm working*, 18 students answered -- Not at all true, 4 students -- Not very true, 1 student -- Sort of true, 2 students – Very true. Collapsed into dichotomous scales: 22 (88%) student – Not true, 3 (12%) students – True.

For Question 16, *When I'm in class, my mind wanders*, 5 students answered -- Not at all true, 8 students -- Not very true, 8 students -- Sort of true, 4 students – Very true. Collapsed into dichotomous scales: 13 (52%) student – Not true, 12 (48%) students – True.

For Question 17, *When I'm in class, I participate in class discussions*, 0 students answered -- Not at all true, 2 students -- Not very true, 9 students -- Sort of true, 14 students – Very true. Collapsed into dichotomous scales: 2 (8%) students – Not true, 23 (92%) students – True.

For Question 18, *When we work on something in class, I feel bored*, 9 students answered -- Not at all true, 8 students -- Not very true, 5 students -- Sort of true, 3 student – Very true. Collapsed into dichotomous scales: 17 (68%) students – Not true, 8 (32%) students – True.

For Question 19, *I don't try very hard at school*, 19 students answered -- Not at all true, 5 students -- Not very true, 0 students -- Sort of true, 1 student – Very true. Collapsed into dichotomous scales: 24 (96%) students – Not true, 1 (4%) student – True.

For Question 20, *I pay attention in class*, 1 student answered -- Not at all true, 0 students -- Not very true, 7 students -- Sort of true, 17 students – Very true. Collapsed into dichotomous scales: 1 (4%) student – Not true, 24 (96%) students – True.

Questions 1, 6, 8, 10, 17, 20 were positively- worded for active engagement: trying hard to do well in school (question 1) and class (question 6), listening carefully (8), getting involved in work, (question 10), participating in classroom discussions (question 17), and paying attention in class (question 20). After collapsing data for these questions into dichotomous scales (True;

Not True), *Data Clusters 2 and 3* emerged. *Cluster 2*: 24 (96%) students trying hard to do well in school (question 1) and class (question 6), paying attention in class (question 20). *Cluster 3*: 23 (92%) students listening carefully (8), getting involved in work, (question 10), and participating in classroom discussions (question 17).

Questions 4, 14, 19 were negatively worded for active engagement: doing just enough to get by (question 4), just act like working (question 14), do not try very hard at school (19). After collapsing data for these questions into dichotomous scales (True; Not True), *Cluster 4* has emerged; it does not have the same unity of answers as *Clusters 2 and 3*, but it measures the same active engagement, just through negatively worded statements that students must reject as untrue to demonstrate their engagement, and its data principally supports the findings in *Clusters 2 and 3*. *Data Cluster 4*: 20 (80%) students answered *Not True* to doing just enough to get by (question 4); 22 (88%) students answered *Not True* to when in class, just acting like they are working (question 14); 24 (96%) students answered *Not True* to not trying very hard at school (question 19).

Data Source 2

A ten-question survey *the Student Classroom Work Rating Scale* (Appendix B) was administered with students to better understand the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students' feeling challenged (productive struggle) and perseverance (ability to complete complex tasks), and additionally to measure students' engagement into Mathematical Practices based on National Council of Teachers of Mathematics (NCTM) Process Standards (NTCM, 2000) and Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013).

Questions 2, 6, and 10 measured a degree of challenge and perseverance; challenge of developing a strategy to solve a problem (question 2); overall challenge of the majority of work in class (question 6); challenge of understanding different mathematical presentations to solve problems in class (question 10). Level of challenge is measured by the entire 5-point *Likert degree scale*, and occurrence of perseverance is being measured by how many students have chosen either *Perfect level of challenge to keep it interesting* or *Higher level of challenge. Took a lot of work, but I solved it*. Questions 1, 3, 4, 5, 7, 8, and 9 measure students' engagement into Mathematical Practices.

Descriptive statistics data from the survey are provided in Tables 3 and 4. To allow for greater data clarity, 5-point Likert scale was collapsed into 3-point *Likert scale*. For questions 1, 3, 4, 5, 7, 8, and 9 a 5-point Likert frequency scale (*Never*, *Almost never, Occasionally/Sometimes, Almost every time, Every time)* was collapsed into 3-point Likert scale by combining *Never* and *Almost never* into *Never* and *Almost every time* and *Every time* into *Every Time*. For questions 2, 6, and 10, a 5-point Likert degree scale (*Not challenging at all; Moderate level of challenge; Perfect level of challenge to keep it interesting; Higher level of challenge. Took a lot of work, but I solved it; Too challenging. Could not solve.)* was collapsed into 3-point Likert scale by combining *Moderate, Perfect,* and *Higher level of challenge* into one category: *Moderate, perfect, or high challenge*.

Table 3

5th and 6th grade Student Classroom Work Rating Scale

5-point Likert Scale										
	Never		Almost Never		Occasionally/ Sometimes		Almost every time		Every time	
	n	%	n	%	n	%	n	%	n	%
Q1	0	0%	1	4%	3	12%	21	84%	0	0%
Q3	0	0%	4	16%	11	44%	10	40%	0	0%
Q4	1	4%	3	12%	11	44%	10	40%	0	0%
Q5	0	0%	3	12%	7	28%	14	56%	1	4%
Q7a	1	4%	0	0%	2	8%	17	68%	5	20%
Q7b	0	0%	1	4%	4	16%	14	56%	6	24%
Q7c	0	0%	0	0%	9	36%	9	36%	7	28%
Q8	0	0%	2	8%	9	36%	13	52%	1	4%
Q9	0	0%	1	4%	9	36%	14	56%	1	4%

Collapsed 3-point Likert scale						
	Never		Occasionally/ Sometimes		Every time	
	n	%	n	%	n	%
Q1	1	4%	3	12%	21	84%
Q3	4	16%	11	44%	10	40%
Q4	4	16%	11	44%	10	40%
Q5	3	12%	7	28%	15	60%
Q7a	1	4%	2	8%	22	88%
Q7b	1	4%	4	16%	20	80%
Q7c	0	0%	9	36%	16	64%
Q8	2	8%	9	36%	14	56%
Q9	1	4%	9	36%	15	60%

Table 4

5th and 6th grade Student Classroom Work Rating Scale: Questions 2, 6, and 10

	5-point Likert scale									
	Not challenging at all		Moderate level of challenge		Perfect level of challenge to keep it interesting		Higher level of challenge. Took a lot of work, but I solved it.		Too challenging. Could not solve	
	n	%	n	%	n	%	n	%	n	%
Q2	0	0%	7	28%	11	44%	6	24%	1	4%
Q6	0	0%	2	8%	13	52%	12	48%	0	0%
Q10	2	8%	2	8%	12	48%	8	32%	1	4%

	Collapsed 3-point Likert scale					
	No Challenge		Moderate, perfect, or high challenge		Too challenging. Could not solve.	
	n	%	n	%	n	%
Q2	0	0%	24	96%	1	4%
Q6	0	0%	25	100%	0	0%
Q10	2	8%	22	88%	1	4%

Appendix B contains a Crosswalk between (NCTM) Process Standards (NTCM, 2000), Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013), and the questions from the *Student Classroom Work Rating Scale*.

Questions from *Student Classroom Work Rating Scale* (Appendix B) were grouped by areas of mathematical process standards (NTCM, 2000) and Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013) with survey data presented using descriptive statistics. Elaboration on the data follows the listing of the results below:

1. *Problem solving* through creating (question 1) and following a strategy (question 2).

Question 1. *Think of all the tasks we worked on in the classroom. Did tasks/problems solving require creating and following a strategy?*

1 (4%) student – Never; 24 (96%) students -- Occasionally/Sometimes (3 students) or Every Time (21 students).

Question 2. *On the occasions you used a strategy to solve a problem, how difficult was it to develop a strategy?*

0 (0%) students – No challenge; 24 (96%) students – Moderate, perfect, or high challenge; 1 (4%) – Too challenging.

2. *Reasoning and proof* by analyzing patterns, making connections (question 3), and finding new creative ways to solve problems (question 4).

Question 3. *Think about all the reasoning and proofs you had to complete for the work in class. Did obtaining the correct answer require*

a) analyzing patterns, structure

b) making connections between parts of the problem?

4 (16%) students – Never; 21 (84%) students -- Occasionally/Sometimes (11 students) or Every Time (10 students).

Question 4. *Think about all the reasoning and proofs you had to complete for the work in class. How often did you or another student at your table come up with new, creative, unusual, or different ways to solve a problem?*

4 (16%) students – Never; 21 (84%) students -- Occasionally/Sometimes (11 students) or Every Time (10 students).

3. *Communication* by working in a group or with a partner to construct arguments, explore solution ideas, find mistakes, offer, or receive help (question 7).

Question 7. *Think of all the work you completed in class while working at your table as a group or with a partner. To what degree did you engage in conversations with other group members while working on this problem to*

a) Explore solution ideas

1 (4%) student – Never; 24 (96%) students -- Occasionally/Sometimes (2 students), Every Time (22 students).

b) Work together to find mistakes

1 (4%) student – Never; 24 (96%) students -- Occasionally/Sometimes (4 students), Every Time (20 students).

c) To better understand the problem

0 (0%) student – Never; 25 (100%) students -- Occasionally/Sometimes (9 students), Every Time (16 students).

4. *Connections* by, while completing work for this class, making connections between different areas of math or even other subjects to solve problems (question 8).

Question 8. *While completing work for this class, to what degree did you need to make connections between different areas of math or even other subjects to solve problems?*

2 (8%) student – Never; 23 (92%) students -- Occasionally/Sometimes (9 students), Every Time (14 students).

5. *Representations* by understanding mathematical ideas presented in multiple ways (question 9), measuring challenge of using different mathematical presentations to solve problems (question 10).

Question 9. *While working on the problems in this class, to what degree did problem solving require understanding mathematical ideas presented in multiple ways: symbols, graphs, tables, pictures, letters, numbers, and other mathematical presentations?*

1 (4%) student – Never; 24 (96%) students -- Occasionally/Sometimes (9 students), Every Time (15 students).

Question 10. *How challenging was it to understand the use of different mathematical presentations to solve problems?*

2 (8%) students – No challenge; 23 (88%) students – Moderate, perfect, or high challenge; 1 (4%) student – Too challenging.

Question 5 (*Think about all the reasoning and proofs you had to complete for the work in class. Did obtaining the correct answer require to use symbols to represent quantities in a problem and to manipulate symbols using mathematical operations to solve a problem?*) is equally related to *Representations* and *Reasoning and Proof* NCTM Process Standards (NTCM, 2000).

3 (12%) student – Never; 22 (88%) students -- Occasionally/Sometimes (7 students), Every Time (15 students).

Question 6 (*Think of the level of difficulty of the majority of work you completed in class. How challenging was that work?*) is related to all 5 NCTM Process Standards (NTCM, 2000) and was added into the survey to specifically measure challenge levels as perceived by students in class.

0 (0%) students – No challenge; 25 (100%) students – Moderate, perfect, or high challenge; 0 (0%) students – Too challenging.

Three more data clusters emerged. *Cluster 5*: degree of challenge (Questions 2, 6, and 10 measuring a degree of challenge and perseverance); *Cluster 6*: occurrence of perseverance (occurrence of perseverance is being measured by how many students have chosen either *Perfect* *level of challenge to keep it interesting* or *Higher level of challenge. Took a lot of work, but I solved it*.); *Cluster 7*: engagement into Mathematical Practices through NCTM Process Standards (NTCM, 2000), Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013) with survey data presented using descriptive statistics.

Cluster 5 (Table 4): degree of challenge (Questions 2, 6, and 10). Challenge of developing a strategy to solve a problem (question 2): 24 (96%) students rated developing a strategy – Moderate, perfect, or high challenge; 1 (4%) student – Too challenging. Overall challenge of the majority of work in class (question 6): 25 (100%) students – Moderate, perfect, or high challenge. Challenge of understanding different mathematical presentations to solve problems in class (question 10): 2 (8%) students – No challenge; 23 (88%) students – Moderate, perfect, or high challenge; 1 (4%) student – Too challenging. Analysis of *Cluster 5* leads to conclusion that during class, 23 to 25 students (88% to 100%) experienced being challenged and were able to persevere.

Data Cluster 6 (Table 4): occurrence of perseverance; How many students have chosen either *Perfect level of challenge to keep it interesting* or *Higher level of challenge. Took a lot of work, but I solved it* for questions 2, 6, and 10. Question 2, challenge of developing a strategy to solve a problem: 17 (58%) students. Question 6, overall challenge of the majority of work in class: 25 (100%) students. Question 10, challenge of understanding different mathematical presentations to solve problems in class: 23 (88%) students. Analysis of *Cluster 6* leads to conclusion that during class, 17 to 25 students (58% to 100%) practiced perseverance while completing their work.

Data Cluster 7 (Table 4): engagement into Mathematical Practices. *Problem solving* through developing a strategy and being challenged when developing a strategy: 24 (96%) students. *Reasoning and proof* by analyzing patterns, making connections (question 3): 21 (84%) students, and finding new creative ways to solve problems (question 4): 21 (84%) students. *Communication* by working in a group or with a partner to construct arguments, explore solution ideas, find mistakes, offer, or receive help (question 7): 24 – 25 students (96 – 100%). *Connections* by while completing work for this class, making connections between different areas of math or even other subjects to solve problems (question 8): 23 (92%) students. *Representations* by understanding mathematical ideas presented in multiple ways (question 9): 24 (96%) students; measuring challenge of using different mathematical presentations to solve problems (question 10): 23 (88%) students. Analysis of *Cluster 7* leads to conclusion that during class, 21 to 25 students (84% to 100%) engagement into Mathematical Practices while completing their work.

Data Source 3

Teacher's Student Observation Scales (Appendix C) was administered once-a-week for four concurrent weeks by the teacher during students' collaborative group work to better understand the level of engagement. The teacher rated students as an observer using direct observation. High-inference variable observed: student behavior and work examined, checking for underlying cognitive and emotional causes -- student is not upset or happy for any other reason than work). Low-inference variable with two ordinal values observed using the signs listed in the *Teacher's Student Observation Scales* (Appendix C): student acting as a participant or student acting as an observer. Student acting as a participant included student appearing to be thinking, interacting with group about their task, writing down the task, asking teacher questions about the task, and paying attention. Student acting as an observer included student copying work of the group, not participating in a discussion, or making suggestions, not completing their own work, not asking for help when struggling. For data clarity, 5-point frequency of occurrence *Likert scale* was collapsed into a 3-point *Likert Scale*: *Never* and *Almost Never* became *Never*, and *Almost Every Time* and *Every Time* became *Every Time*. Data yielded from the teacher observations is presented in Table 5 using descriptive statistics.

Table 5

Teacher's Student Observation Scales for 5th and 6th grades

5-point Likert scale										
	Never		Almost never		Occasionally/ Sometimes		Almost every time		Every time	
	n	%	n	%	n	%	n	%	n	%
Q1a	0	0%	4	4%	15	15%	37	37%	44	44%
Q1b	0	0%	3	3%	19	19%	38	38%	40	40%
Q1c	0	0%	3	3%	10	10%	33	33%	54	54%
Q1d	6	6%	23	23%	48	48%	12	12%	11	11%
Q1e	0	0%	3	3%	16	16%	39	39%	42	42%
Q2a	0	0%	3	3%	5	5%	12	12%	80	80%
Q2b	78	78%	3	3%	16	16%	2	2%	1	1%
Q2c	0	0%	1	1%	5	5$	11	11%	72	72%
Q2d	1	1%	6	6%	5	5%	19	19%	69	69%
Q2e	2	2%	13	13%	19	19%	61	61%	5	5%

Collapsed 3-point Likert scale						
	Never		Occasionally/ Sometimes		Every time	
	n	%	n	%	n	%
Q1a	4	4%	15	15%	81	81%
Q1b	3	3%	19	19%	78	78%
Q1c	3	3%	10	10%	87	87%
Q1d	29	29%	48	48%	23	23%
Q1e	3	3%	16	16%	81	81%
Q2a	3	3%	5	5%	92	92%
Q2b	81	81%	16	16%	3	3%
Q2c	1	1%	5	5%	83	83%
Q2d	7	7%	5	5%	88	88%
Q2e	15	15%	19	19%	66	66%

As each of the 25 students was observed 4 times, 100 observations for 5th and 6th grade students were recorded by the educator/researcher during class.

Section 1. *Student acts as a participant*

b) Appears to be thinking: 4 (4%) observed occurrences – Never; 15 (15%) observed occurrences – Occasionally/Sometimes; 81 (81%) observed occurrences – Every time.

c) Writes down work: 3 (3%) observed occurrences – Never; 19 (19%) observed occurrences – Occasionally/Sometimes; 78 (78%) observed occurrences – Every time.

d) Interacts with their group about the task: 3 (3%) observed occurrences – Never; 10 (10%) observed occurrences – Occasionally/Sometimes; 87 (87%) observed occurrences – Every time.

e) Asks teacher questions about the task: 29 (29%) observed occurrences – Never; 48 (48%) observed occurrences – Occasionally/Sometimes; 23 (23%) observed occurrences – Every time.

f) Pays attention: 3 (3%) observed occurrences – Never; 16 (16%) observed occurrences – Occasionally/Sometimes; 81 (81%) observed occurrences – Every time.

Section 2. *Student acts like an observer*

a) Completes their own work: 3 (3%) observed occurrences – Never; 5 (5%) observed occurrences – Occasionally/Sometimes; 92 (92%) observed occurrences – Every time.

b) Copies work of the group: 91 (0%) observed occurrences – Never; 6 (6%) observed occurrences – Occasionally/Sometimes; 3 (3%) observed occurrences – Every time.

c) Participates in discussion: 1 (1%) observed occurrences – Never; 5 (5%) observed occurrences – Occasionally/Sometimes; 94 (94%) observed occurrences – Every time.

d) Makes suggestions: 7 (7%) observed occurrences – Never; 5 (5%) observed occurrences – Occasionally/Sometimes; 88 (88%) observed occurrences – Every time.

e) Asks for help when struggling with a problem: 15 (15%) observed occurrences – Never; 19 (19%) observed occurrences – Occasionally/Sometimes; 66 (66%) observed occurrences – Every time.

Data *Cluster 8*: high engagement observable behaviors. This data cluster was formed from teacher observations of students' engagement during class. Students demonstrated high engagement observable behaviors. Out of 100 observations made, 4 observations per student, 87% of the time students were interacting with a group about a task (question 1d); completing their work 92 - 97% of the time (question 2a); participating in a discussion 94 – 99 % of the time (question 2c) and making suggestions 88 – 93% of the time (question 2d).

On the *Teacher's Student Observation Scales* (Appendix C), low-inference variables were included into the questions the teacher rated on a *5-point Likert scale* (Appendix C; Table 5) and high-inference variables were included into teacher notes made during observation time. High-inference variables covered underlying cognitive and emotional causes of students being upset or happy for reasons other than work. Two causes that were noted during teacher observations encompassed some students experiencing fear and frustration with the COVID-19 pandemic, mask wearing, social distancing rules, and quarantine, and some students being concerned about their level of giftedness as compared to others in class.

Data Source 4

Using *Achievement Chart* (Appendix D), de-identified student data was collected from student records and classwork by the teacher to better understand students' level of achievement through grades in a regular math class; Stanford University math software RedBird Math grade level and proficiency achievement rankings; percentage of correctly completed, and percentage of attempted classwork for the duration of the study. The data was placed into Table 6 for 5th grade students and Table 7 for 6th grade students. Stanford University RedBird Math Software that students worked on during GATE (Gifted and Talented Education) math class PLT (Personalized Learning Time) as part of the *Internally Designed Mathematics Differentiation System for Gifted and Talented 5th and 6th Grade Students* has three proficiency rankings for the current work students are engaged in: proficient, non-proficient, and current, with proficient being the highest ranking. In summary, 100% of 5th and 6th grade program participants were ranked as proficient by the RedBird Math Software.

Table 6

Achievement Chart for 5th grade students

Student's de-identified Code Number	Quarter 1 grade In a regular math class	Quarter 2 grade In a regular math class	Quarter 3 grade In a regular math class	RedBird Math Achievement Ranking	Percentage of correctly completed math work in GATE class	Percentage of attempted Classwork
510	97	99	100	Grade 7 proficient	95%	100%
520	97	98	98	Grade 5 proficient	100%	100%
530	99	100	100	Grade 7 proficient	90%	100%
540	93	91	95	Grade 6 proficient	90%	100%
550	94	98	97	Grade 6 proficient	95%	100%
560	98	100	97	Grade 6 proficient	100%	100%
570	100	95	100	Grade 6 proficient	95%	100%
580	98	99	100	Grade 6 proficient	90%	100%
590	97	95	96	Grade 6 proficient	95%	100%
521	90	100	99	Grade 6 proficient	100%	100%
522	98	93	93	Grade 5 proficient	80%	80%
523	90	94	93	Grade 5 proficient	95%	95%
524	100	97	98	Grade 5 proficient	65%	65%

Table 7

Achievement Chart for 6th grade students

Student's de-identified Code Number	Quarter 1 grade In a regular math class	Quarter 2 grade In a regular math class	Quarter 3 grade In a regular math class	RedBird Math Achievement Ranking	Percentage of correctly completed math work in GATE class	Percentage of attempted Classwork
620	92	83	90	Grade 6 proficient	75%	75%
621	98	100	98	Grade 6 proficient	100%	100%
622	90	95	96	Grade 7 proficient	100%	100%
623	100	98	98	Grade 6 proficient	95%	95%
624	96	89	90	Grade 6 proficient	100%	100%
625	93	95	97	Grade 6 proficient	85%	85%
626	97	100	99	Grade 7 proficient	95%	100%
627	94	94	96	Grade 6 proficient	95%	100%
630	100	96	100	Grade 7 proficient	95%	100%
631	99	100	100	Grade 7 proficient	100%	100%
632	95	97	96	Grade 6 proficient	70%	70%
633	96	96	96	Grade 6 proficient	95%	95%

Data from the *Achievement Chart* (Tables 6 and 7) shows that 4 out of 13 fifth grade students were doing math work in RedBird on the 5th grade math level; 7 were doing 6th grade work, and 2 were doing 7th grade work. Out of 12 sixth grade students, 8 were doing 6th grade math work in RedBird, and 4 students were doing 7th grade work. That is 10 (40%) out of 25 students working above their grade level, with 2 (8%) out of 25 students doing work 2 grades above their grade level.

Data shows that 20 (80%) out of 25 students attempted 95% and above of all work in the gifted math program; 5 (20%) out of 25 students attempted between 65% to 85% of all the work in the gifted math program.

Data shows that 20 (80%) out of 25 students correctly completed from 90 -- 100% of all the work in the gifted math program; 5 (20%) out of 25 students correctly completed between 65 – 85% of all the work in the gifted math program.

Based on the data from each of the 25 students' grades in a regular math class for quarters 1, 2, and 3 (75 grades; 3 per student), 67 (89.3%) grades were As, 7 (9.3%) were Bs, and 1 (1.3%) was C.

Data Cluster 9 emerged: 100% of students attempted 65 – 95% of all work in the gifted math program, with 20 (80%) out of 25 students attempting 95%. 100% of students correctly completed 65 – 100% of all work in the gifted math program, with 20 (80%) out of 25 students correctly completing 90 -- 100% of all the work in the gifted math program.

Data Source 5

Each of 25 students was asked to rate 20 different tasks they worked on during the research timeframe using a single-question survey (Appendix E), 5-point *Level of Difficulty Likert Scale to Measure Challenge*, which measured students' feeling of being challenged (productive struggle) in class. For the duration of research, 500 tasks were rated. In addition to measuring challenge, an occurrence of perseverance was measured by collecting data on how many students have chosen either *Perfect level of challenge to keep it interesting* or *Higher level of challenge. Took a lot of work, but I solved it* answers within this survey.

Survey data were collected by the researcher and presented using descriptive statistics in Table 8. For greater data clarity, a 5-point *Likert degree scale* (*Not challenging at all; Moderate* *level of challenge; Perfect level of challenge to keep it interesting; Higher level of challenge. Took a lot of work, but I solved it; Too challenging. Could not solve.)* was collapsed into 3-point *Likert scale* by combining *Moderate, Perfect,* and *Higher level of challenge* into one category: *Moderate, perfect, or high challenge*. Data yielded from rating 20 tasks each by 25 students for a total of 500 tasks: 32 (6.4%) tasks – No challenge; 427 (85.4%) tasks – Moderate, perfect, or high challenge; 41 (8.2%) tasks – Too challenging. Occurrence of perseverance: 349 (69.8%) tasks were rated *Perfect,* and *Higher level of challenge.*

Table 8

Level of Difficulty Likert Scale to Measure Students' Challenge in 20 Tasks: *5th and 6th grades combined*

	5-point Likert scale									
	Not challenging at all		Moderate level of challenge		Perfect level of challenge to keep it interesting		Higher level of challenge. Took a lot of work, but I solved it.		Higher level of challenge. Took a lot of work, but I solved it.	
	n	%	n	%	n	%	n	%	n	%
Q1	32	6.4%	78	15.6%	163	32.6%	186	37.2	41	8.2%
	Collapsed 3-point Likert scale									
	No Challenge		Moderate, perfect, or high challenge						Too challenging. Could not solve.	
	n	%	n				%		n	%
Q1	32	6.4%	427				85.4%		41	8.2%

Analysis of data in Table 8, allowed for the emergence of *Data Cluster* 10: 427 (85.4%) tasks – Moderate, perfect, or high challenge; 41 (8.2%) tasks – Too challenging. Occurrence of perseverance: 349 (69.8%) tasks were rated *Perfect,* and *Higher level of challenge.*

Summary

After surveying the data from five data sources and identifying ten data clusters, four themes emerged on what is the impact of an *Internally Designed Mathematics Differentiation System* on gifted and talented 5th and 6th grade students. The four themes align with research sub-questions: 1) participation in a school's gifted math program brought a significant joy and high level of engagement to 5th and 6th gifted students; 2) high level of engagement and joy aligned with similar percentage of students feeling challenged, having access to, being able to solve challenging tasks in class; 3) the occurrence of perseverance, an ability to solve challenging tasks, is connected to solving a significant number of challenging tasks through high level of engagement into mathematical process standards, collaborative work, and feeling of joy and interest in such work; 4) high level of achievement is accompanied by similar levels of collaborative work, a feeling of joy and interest in class, and a feeling of being challenged.

Discussion

This study examined the impact of the *Internally Designed Mathematics Differentiation System* on gifted 5th and 6th grade students' feeling of joy (social-emotional aspect) in class, feeling challenged (productive struggle), perseverance (ability to complete complex tasks), and achievement (grades, achievement ratings). The research question of the study has been answered through the analysis of five research designated data sources: *Engagement Versus Disaffection with Learning* (Skinner et. al., 2008; Appendix A; Tables 1 & 2); *Student Classroom Work Rating Scale* (Appendix B; Table 3 & 4); *Teacher's Student Observation Scales* (Appendix C; Table 5; *Achievement Chart* (Appendix D, Table 6 & 7); *Level of Difficulty Likert Scale to Measure Students' Challenge in 20 Tasks* (Appendix E; Table 8).

Four themes that emerged from the ten *Data Clusters* identified by the descriptive statistics research analysis reveal the impact of an *Internally Designed Mathematics*

Differentiation System on gifted and talented 5th and 6th grade students: 1) participation in a school's gifted math program brought a significant joy and high level of engagement to 5th and 6th gifted students; 2) high level of engagement and joy aligned with similar percentage of students feeling challenged, having access to, being able to solve challenging tasks in class; 3) the occurrence of perseverance, an ability to solve challenging tasks, is connected to solving a significant number of challenging tasks through high level of engagement into mathematical process standards, collaborative work, and feeling of joy and interest in such work; and 4) high level of achievement is accompanied by similar levels of collaborative work, a feeling of joy and interest in class, and a feeling of being challenged.

Themes Aligned with Research Sub-Questions

Theme One: Participation in a School's Gifted Math Program Brought a Significant Joy and High Level of Engagement to 5th and 6th Gifted Students

Theme one (participation in a school's gifted math program brought a significant joy and high level of engagement to 5th and 6th gifted students) opens a perspective on sub-question one: how participation in the *Internally Designed Mathematics Differentiation System* affected students' feelings in regard to joy (social-emotional aspect). *Data Cluster 1* from *Engagement Versus Disaffection with Learning* (Skinner et. al., 2008; Appendix A; Tables 1 & 2) showed that 22 students (88%) enjoyed learning new things in class, thought class was fun, and felt good in class. *Cluster 1* data came from collapsing data for positively worded questions 2, 5, and 15 into dichotomous scales (True; Not True).

Skinner et al. (2008) *Engagement Versus Disaffection with Learning* was used specifically because it measured not just feelings of joy or the degree of its presence or absence, it measured behavioral engagement, behavioral disaffection, emotional engagement, and emotional disaffection (Skinner et al.)), allowing students to express and rate their feelings of interest of joy, but also boredom, frustration, and to rate work engagement or avoidance.

Data Clusters 2 and 3, from questions positively worded about engagement, showed that 24 (96%) students trying hard to do well in school (question 1) and class (question 6), paying attention in class (question 20), and that 23 (92%) students were listening carefully (8), getting involved in work, (question 10), and participating in classroom discussions (question 17). Data from *Cluster 4*, with questions negatively worded about engagement, 20 (80%) students answered *Not True* to doing just enough to get by (question 4); 22 (88%) students answered *Not True* to when in class, just acting like they are working (question 14); 24 (96%) students answered *Not True* to not trying very hard at school (question 19).

The comparison between the data from Clusters 1, 2, 3, and 4 showed that 22 students (88%) enjoyed learning new things in class, thought that class was fun, and felt good in class, and thus aligns with high engagement of 23 - 24 (92 - 96%) students trying hard to do well in school and class, paying attention in class, listening carefully, getting involved in work, and participating in classroom discussions. Consequently, between 20 - 24 (80 - 96%) students answered *Not True* to doing just enough to get by; answered *Not True* to, when in class, just acting like they are working; and answered *Not True* to not trying very hard at school.

The above data showed that emotional engagement closely aligned with behavioral engagement, and that emotional disaffection closely aligned with behavioral disaffection. Emotional engagement and behavioral engagement were co-present in most of the class. Theme one data supported one of Literature Review findings that access to and participation in gifted programs on mathematically talented students is not a luxury and has a significant impact on their social-emotional well-being.

While working on the *Teacher's Student Observation Scales* (Appendix C), low-inference variables were included into the questions the teacher rated on a *5-point Likert scale* (Appendix C; Table 5); high-inference variables observed were included into teacher notes made during observation time described in Appendix C: underlying cognitive and emotional causes of students being upset or happy for reasons other than work. Two causes came as central during teacher observations: 1) some students experienced fear and frustration with the COVID-19 pandemic, mask wearing, social distancing rules, and quarantine, 2) some students were concerned about their level of giftedness as compared to others in class, seeing that other students were able to solve challenging tasks faster with more ease, grasp difficult concepts faster, and move on to harder work before anyone else in class. Two students who marked feeling bad in class were especially concerned with their "who is smarter" standing in class. One of the students who marked several choices for feeling bad, worried, and not working hard had just experienced the death of a family pet. No other underlying causes of students feeling upset or happy for reasons other than work were noted.

Theme Two: High Level of Engagement and Joy Is Aligned with Similar Percentage of Students Feeling Challenged, Having Access to, and Being Able to Solve Challenging Tasks in Class

Theme two (high level of engagement and joy aligned with similar percentage of students feeling challenged, having access to, and being able to solve challenging tasks in class) opens a perspective on sub question two: how participation in the *Internally Designed Mathematics Differentiation System* affected students experiencing feeling challenged (productive struggle). Analysis of *Cluster 5* lead to conclusion that during class, 23 to 25 students (88% to 100%) experienced being challenged and were able to persevere and solve the tasks they were working on. Data from *Cluster 10* demonstrated that 427 (85.4%) tasks were rated by students as

Moderate, perfect, or high challenge, with 41 (8.2%) tasks – *Too challenging*, with occurrence of perseverance in 349 (69.8%) tasks rated by students as *Perfect,* and *Higher level of challenge.*

Data *Cluster 5* came from *the Student Classroom Work Rating Scale* (Appendix B; Tables 3 & 4) where students rated overall all the work they completed in class, while data *Cluster 10* came from the *Level of Difficulty Likert Scale to Measure Students' Challenge in 20 Tasks* (Appendix E; Table 8) where students individually rated each of the twenty tasks – as students were rating tasks, curriculum was constantly adjusted to serve the needs of individual students – raising levels of challenge for students rating tasks as moderately challenging or not challenging; lowering level of challenge and providing additional assistance to students finding some of the tasks too challenging; accelerating or slowing down as needed, materials added to better serve students' strengths and interests, as students worked to meet their learning and instructional goals. Based on the shift between students' rating of the individual tasks and students' overall assessment of the program, with fewer students found classwork too challenging or too easy work after the teacher made continuous curriculum adjustments, 23 – 25 students (88% to 100%) experienced being challenged and were able to persevere and solve the tasks they were working on.

The data imparted from *Clusters 5* and *10* conveys that after 427 (85.4%) tasks were rated by students as *Moderate, perfect, or high challenge*, with the continuous curriculum adjustments based on students' academic needs, 23 to 25 students (88% to 100%) experienced being challenged and were able to persevere and solve the tasks they were working on. Data from *Clusters 1, 2, 3,* and *4* showed that 22 students (88%) enjoyed learning new things in class, thought that class was fun, and felt good in class, and thus aligns with high engagement of 23 -

24 (92 - 96%) students trying hard to do well in school and class, paying attention in class, listening carefully, getting involved in work, and participating in classroom discussions.

The joined data from *Clusters 1, 2, 3, 4, 5*, and *10* demonstrates that one of the impacts of the high level of engagement and joy in a program is that it is aligned with similar percentage of students feeling challenged, having access to, and being able to solve challenging tasks in class. These results support the Literature Review findings that learning opportunities must match student's level of ability instead of age and grade-level and should include collaborative learning opportunities with like ability peers.

Theme Three: The Occurrence of Perseverance, an Ability to Solve Challenging Tasks, Is Connected to Solving a Significant Number of Challenging Tasks Through High Level of Engagement into Mathematical Process Standards, Collaborative Work, and Feeling of Joy and Interest in Such Work

Theme three (the occurrence of perseverance, an ability to solve challenging tasks, is connected to solving a significant number of challenging tasks through high level of engagement into mathematical process standards, collaborative work, and feeling of joy and interest in such work) opens a perspective on sub question three: how participation in the *Internally Designed Mathematics Differentiation System* affected students' perseverance (ability to complete complex tasks). Analysis of *Cluster 6* from *Student Classroom Work Rating Scale* (Appendix B; Table 4) leads to conclusion that during class, 17 to 25 students (58% to 100%) practiced perseverance while completing their work. Concurrently, data from *Cluster 10* that came from the *Level of Difficulty Likert Scale to Measure Students' Challenge in 20 Tasks* (Appendix E; Table 8) established that out of 500 tasks individually rated by students, at the rate of 20 tasks per student, 427 (85.4%) tasks were rated as *Moderate, perfect, or high challenge,* and 41 (8.2%) tasks – *Too* *challenging*. The occurrence of perseverance was established when tasks were rated *Perfect,* and *Higher level of challenge* -- 349 (69.8%) of all tasks. Perfect level tasks were described in the surveys as *Perfect level of challenge to keep it interesting*, and high level of challenge tasks as -- *Higher level of challenge. Took a lot of work, but I solved it.* The *Student Classroom Work Rating Scale* (Appendix B) was developed based on the areas of mathematical process standards (NTCM, 2000) and Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (Johnsen & Sheffield, 2013); all include developing perseverance into the mathematical process standards.

Data *Cluster 8* formed from the *Teacher's Student Observation Scales* (Appendix C; Table 5), teacher observations of students' engagement during class. Out of 100 observations made, 4 observations per student, 87% of the time students were interacting with a group about a task; completing their work 92 - 97% of the time; participating in a discussion 94 – 99 % of the time and making suggestions 88 – 93% of the time.

Data Cluster 1 from *Engagement Versus Disaffection with Learning* (Skinner et al., 2008; Appendix A; Tables 1 & 2) showed that 22 students (88%) enjoyed learning new things in class, thought class was fun, and felt good in class.

Together, *Data Clusters 1, 6, 8* and *10* reveal that high level of engagement (87 – 99% of students interacting with a group about a task; completing their work; participating in a discussion, and making suggestions), is aligned with students working on tasks they rated as *Moderate, perfect, or high challenge* 85.4% of the time; experiencing perseverance in 69.8% of all tasks, and 88% of the students enjoying learning new things in class, thinking class was fun, and feeling good in class.

The joined data from *Clusters 1, 6, 8* and *10* reveals that the occurrence of perseverance, an ability to solve challenging tasks, is connected to solving a significant number of challenging tasks through high level of engagement into mathematical process standards, collaborative work, and feeling of joy and interest in such work.

These results support the Literature Review findings that access to and participation in gifted programs for mathematically talented students is not a luxury and has a significant impact on their social-emotional well-being (Cross, 2014), degree of engagement (Reis $ Coach, 2000), and opportunities for domain talent development (Bloom $ Sosniak, 1991).

Theme Four: High Level of Achievement Is Accompanied by Similar Levels of Collaborative Work, a Feeling of Joy, an Interest in Class, and a Feeling of Being Challenged

Theme four (high level of achievement is accompanied by similar levels of collaborative work, a feeling of joy and interest in class, and a feeling of being challenged) opens a perspective on sub question four: how participation in the *Internally Designed Mathematics Differentiation System* affected students' achievement (grades in math and percentage of successfully completed tasks).

Data *Clusters 8, 9* show 87% students interacting with a group about a task; completing their work 92 - 97% of the time; participating in a discussion 94 – 99 %, making suggestions 88 – 93% of the time (*Cluster 8*); 100% of students attempted 65 – 95% of all work in the gifted math program, with 20 (80%) out of 25 students attempting 95%; 100% of students correctly completed 65 – 100% of all work in the gifted math program, with 20 (80%) out of 25 students correctly completing 90 -- 100% of all the work in the gifted math program (*Cluster 9*).

What's more, data from the *Achievement Chart* (Appendix D; Tables 6 and 7) shows that 4 out of 13 fifth grade students were doing math work in RedBird on the 5th grade math level; 7

were doing 6th grade work, and 2 were doing 7th grade work. Out of 12 sixth grade students, 8 were doing 6th grade math work in RedBird, and 4 students were doing 7th grade work. That is 10 (40%) out of 25 students working above their grade level, with 2 (8%) out of 25 students doing work 2 grades above their grade level. Based on the data from each of the 25 students' grades in a regular math class for quarters 1, 2, and 3 (75 grades; 3 per student), 67 (89.3%) grades were As, 7 (9.3%) were Bs, and 1 (1.3%) was C.

Data *Clusters 8, 9* and the data from the *Achievement Chart* (Appendix D; Tables 6 and 7) shows students interacting with a group about a task, participating in a discussion, correctly completing their work, and attempting new work at high rates, with (40%) out of 25 students working above their grade level, and earning As and Bs in a regular math class 98.6 % times.

While there is no direct link between students' feeling of joy, high engagement in a program, feeling of being challenged, and achievement in a regular math class, it is at least a frequent co-occurrence. At the same time, data clearly shows that high level of achievement in RedBird Math and other work done as part of the *Internally Designed Mathematics Differentiation System* is accompanied by similar levels of collaborative work, a feeling of joy and interest in class, and a feeling of being challenged, as supported by the data in *Clusters 1 – 10.*

The data from themes one through four supports the research from the Literature Review findings:

1) access to and participation in gifted programs for mathematically talented students support students' social-emotional well-being (Cross, 2014; Reis & Coach, 2000; Winner 2003) and feeling of joy, generate satisfaction with a program, high student engagement, and contribute to domain talent development (Bloom & Sosniak, 1991),

2) access to challenging materials with opportunity to practice perseverance aids domain talent development (Bloom, 1985; Lubinski & Benbow, 2006; Gavin & Sheffield, 2010) and sustain high achievement levels (Lubinski & Benbow, 2006) in both regular math class and gifted math program,

3) there are clear academic and social-emotional benefits to students from documentation of effective program development methods (Weinberg et al., 2011), adherence to and usage of national gifted program standards (NAGC), and internal evaluations of gifted programs at schools for student growth, satisfaction, and social-emotional well-being (Lubinski & Benbow, 2006; Jones, 2011; Boazman & Sayer, 2011; VanTassel-Baska, 2019).

Limitations and Delimitations

One of the most obvious limitations of this study is its size: 25 participants is a number that cannot produce any statistically significant results even with random assignment, which was not the case in this study. Out of 25 participants, 24 were boys and 1 was a girl, so there was no opportunity to observe potential gender differences in joy, achievement, perseverance, or rating of work for challenge. The study was local, and the researcher was the author of the *Internally Designed Mathematics Differentiation System* and the classroom teacher at the same time. It was my first year teaching the program I created based on the input from parents, students, school's principal, MNPS Gifted and Talented office, twenty years of experience in the field of education, and the research completed during graduate studies for Specialist in Gifted Education and Talent Development at Western Kentucky University. While being the program's creator, teacher and researcher had its benefits like being able to react in real time to my students' academic needs and interests, fully understanding the programs goals and the research behind it, it also coincided with this study being a local action research designed to answer unique demographic needs of one community and to answer specific academic needs of one school's gifted population of 5th and 6th grade students. Additionally, the delimitations of the study were that being program's creator, teacher and researcher could have introduced subconscious bias into data interpretation – in order to minimize its occurrence, the study relied predominately on quantitative data collection methods.

Implications for Future Research

What was learned by the action researcher studying the impact of the *Internally Designed Mathematics Differentiation System* is that high levels of joy and social-emotional well-being coincide with significant levels of feeling academically challenged for gifted students: 23 to 25 students, 88 - 100% (*Data Cluster 5*), experienced being challenged and were able to persevere and solve the tasks they were working on; 85.4% of tasks being rated by students as *Moderate, perfect, or high challenge* co-occurred with 88% of students enjoying learning new things in class, thinking class was fun, and feeling good in class, at the same time as a significant majority of classroom work required perseverance to be able to complete (69.8% tasks rated *Perfect,* and *Higher level of challenge).*

It was important to use an instrument for measuring students' experience *Engagement Versus Disaffection with Learning* that measured not only feelings of joy or the degree of its presence or absence, but it also measured behavioral engagement, behavioral disaffection, emotional engagement, and emotional disaffection (Skinner et al., 2008). It allowed students to express and rate their feelings of interest of joy, but also boredom, frustration, and to rate both work engagement and avoidance, bringing my attention to the intensity of students' feelings on the opposite sides of the spectrum. If an instrument that only measured the degree of positive emotions was used, the results would have potentially missed out on the presence of negative emotions in some of the students, and the researcher would not have been able to fuller understand a more complete social-emotional layout of my classroom. Given the high levels of observable intensities (Piechowski, 2006; Sisk, 2018) in the gifted classrooms and a high capacity of gifted students for a wide range of feelings, it is important for an educator to be aware of intensities and to know how to channel and support intensities to bolster healthy gifts and talents development, mental well-being, and positive self-esteem of gifted students (Sisk, 2018).

If the study were to be repeated, it would be advisable to replicate the study in a situation with more female students present, more students of color, English language learner students, twice-exceptional gifted students, and in several schools simultaneously, done by multiple gifted educators who could collaborate on analyzing the data that could have statistically significant results for different schools and demographic populations in our district.

The major implications of this study, supported by its data and research completed for the Literature Review, was that the impact of the *Internally Designed Mathematics Differentiation System* on gifted 5th and 6th grade students demonstrated that high levels of joy and social-emotional well-being in gifted students is connected to the opportunity to experience significant levels of academic challenge in the domain of their talent and/or interest, and that an opportunity to practice perseverance at high levels during class is aligned with high levels of engagement and collaborative work opportunities with gifted peers, while coinciding with high levels of achievement in that domain.

Conclusion

This study examined the impact of the *Internally Designed Mathematics Differentiation System* on gifted 5th and 6th grade students' feeling of joy (social-emotional aspect) in class, feeling challenged (productive struggle), perseverance (ability to complete complex tasks), and achievement (grades, achievement ratings). The program was created to give gifted 5th and 6th grade students an opportunity to be challenged in the field of mathematics to normalize the amount of effort it takes to be exceptional in mathematics, provide a safe place to make mistakes, encourage developing persistence as a vital quality of a mathematician, introduce students to the history of mathematics, examine the development of key mathematical ideas throughout the history of mankind and learn how mathematical ideas contributed to the world's science, technology, and culture, and strengthen mathematical reasoning (primarily focus on algebraic reasoning), critical thinking, and computational skills through solving puzzles, cognitive tasks, challenging logic, and mathematical problems.

The goal of the study was to measure and understand *Internally Designed Mathematics Differentiation System's* impact on my students to improve it for future use, potential collaboration with other gifted educators in my district, and to grow professionally as a practitioner and researcher in the field of gifted and talented education.

The findings of the study support prior research in the field that established that the general theoretical framework of mathematical talent development suggests that learning opportunities must match student's level of ability instead of age and grade-level (Stanley & Benbow, 1982; Stambaugh & Benbow, 2010); should include collaborative learning opportunities with like-ability peers (Lupkowski-Shoplik, 2010; Bloom & Sosniak, 1981), that access to and participation in gifted programs on mathematically talented students is not a luxury and has a significant impact on their social-emotional well-being, mental health (Cross, 2014; Hollingworth, 1942; Janos & Robinson, 1985; Winner, 2003), degree of talent development (Reis & Coach, 2000; Kettler, 2016), and opportunities later in life (Stanley & Benbow, 1982), and that access to challenging materials with opportunity to practice perseverance sustains high achievement levels in both regular math class and gifted math program (Bloom & Sosniak, 1991; Assouline & Lupkowski-Shoplik, 2005), and gifted program development benefits from documentation of effective program practice and development methods, adherence to and usage of national program standards (NAGC), and internal evaluations of gifted programs at schools for student growth, satisfaction, and social-emotional well-being (VanTassel-Baska,1992).

The findings of the study also establish that participation in the *Internally Designed Mathematics Differentiation System* positively impacted gifted and talented 5^{th} and 6^{th} grade gifted students, with students demonstrating that high levels of joy and social-emotional well-being in gifted students are connected to the opportunity to experience significant levels of academic challenge in the domain of their talent and/or interest, and that an opportunity to practice perseverance at high levels during class is aligned with high levels of engagement and collaborative work opportunities with gifted peers, while coinciding with high levels of achievement in that domain.

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APPENDIX A

Engagement vs. Disaffection with Learning Student-report Behavioral Engagement

How I Feel About School

When answering questions on this survey, please think only about the GATE math pull-out program.

1. I try hard to do well in school.

A) Not at all true B) Not very true C) Sort of true D) Very true

2. I enjoy learning new things in class.

A) Not at all true B) Not very true C) Sort of true D) Very true

3. When we work on something in class, I feel discouraged.

A) Not at all true B) Not very true C) Sort of true D) Very true

4. In class, I do just enough to get by.

A) Not at all true B) Not very true C) Sort of true D) Very true

5. Class is fun.

A) Not at all true B) Not very true C) Sort of true D) Very true

6. In class, I work as hard as I can.

A) Not at all true B) Not very true C) Sort of true D) Very true

7. When I'm in class, I feel bad.

A) Not at all true B) Not very true C) Sort of true D) Very true

8. When I’m in class, I listen very carefully.

A) Not at all true B) Not very true C) Sort of true D) Very true

9. When I’m in class, I feel worried.

A) Not at all true B) Not very true C) Sort of true D) Very true

10. When we work on something in class, I get involved.

A) Not at all true B) Not very true C) Sort of true D) Very true

11.When I’m in class, I think about other things.

A) Not at all true B) Not very true C) Sort of true D) Very true

12. When we work on something in class, I feel interested.

A) Not at all true B) Not very true C) Sort of true D) Very true

13. Class is not all that fun for me.

A) Not at all true B) Not very true C) Sort of true D) Very true

14. When I’m in class, I just act like I’m working.

A) Not at all true B) Not very true C) Sort of true D) Very true

15. When I’m in class, I feel good.

A) Not at all true B) Not very true C) Sort of true D) Very true

16. When I’m in class, my mind wanders.

A) Not at all true B) Not very true C) Sort of true D) Very true

17. When I'm in class, I participate in class discussions.

A) Not at all true B) Not very true C) Sort of true D) Very true

18. When we work on something in class, I feel bored.

A) Not at all true B) Not very true C) Sort of true D) Very true

19. I don't try very hard at school.

A) Not at all true B) Not very true C) Sort of true D) Very true

20. I pay attention in class.

A) Not at all true B) Not very true C) Sort of true D) Very true

APPENDIX B

Student Classroom Work Rating Scale -- to be given once at the end of the research period.

Student Classroom Work Rating Scale was created based on The National Council of Teachers of Mathematics (NCTM) Process Standards (12752_Exec Summary_v3 (nctm.org)), taking into consideration Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners (National Association for Gifted Children; Johnsen & Sheffield, Using the Common Core State Standards for Mathematics with Gifted and Advanced Learners), NAGC Pre-K-Grade 12 Gifted Programming Standards, and adapted into Student Classroom Work Rating Scale questions for gifted and talented 5-6th grade math students.

Problem Solving.

Question 1. Think of all the tasks we worked on in the classroom. Did tasks/problems solving require creating and following a strategy?

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(Frequency of Use Likert Scale **to measure occurrence)**

Question 2. On the occasions you used a strategy to solve a problem, how difficult was it to develop a strategy?

1 - Not challenging at all, 2 - Moderate level of challenge, 3 - Perfect level of challenge to keep it interesting, 4 - Higher level of challenge. Took a lot of work, but I solved it, 5 - Too challenging, could not solve.

(Level of Difficulty Likert Scale **to measure challenge**)

Reasoning and Proof.

Question 3. Think about all the reasoning and proofs you had to complete for the work in class. Did obtaining the correct answer require

a) analyzing patterns, structure
b) making connections between parts of the problem?

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(*Frequency of Use Likert Scale* **to measure occurrence)**

Question 4. Think about all the reasoning and proofs you had to complete for the work in class. How often did you or another student at your table come up with new, creative, unusual, or different ways to solve a problem?

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(*Frequency of Use Likert Scale* **to measure occurrence)**

Reason abstractly and quantitatively.

Question 5. Think about all the reasoning and proofs you had to complete for the work in class. Did obtaining the correct answer require to

c) use symbols to represent quantities in a problem and to manipulate symbols using mathematical operations to solve a problem

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(*Frequency of Use Likert Scale* **to measure occurrence)**

Challenge

Question 6. Think of the level of difficulty of the majority of work you completed in class. How challenging was that work?

1 - Not challenging at all, 2 - Moderate level of challenge, 3 - Perfect level of challenge to keep it interesting, 4 - Higher level of challenge. Took a lot of work, but I solved it, 5 - Too challenging, could not solve.

(NAGC Pre-K-Grade 12 Gifted Programming Standards. 4.1.1. Educators maintain high expectations for all students with gifts and talents as evidenced in meaningful and challenging activities.)

(*Level of Difficulty Likert Scale* **to measure challenge)**

Communication

Question 7. Think of all the work you completed in class while working at your table as a group or with a partner. To what degree did you engage in conversations with other group members while working on this problem to:

a) Explore solution ideas

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

b) Work together to find mistakes

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

c) To better understand the problem

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

d) To offer or receive help

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(*Frequency of Use Likert Scale* **to measure occurrence)**

Making Connections

Question 8. While completing work for this class, to what degree did you need to make connections between different areas of math or even other subjects to solve problems?

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(*Frequency of Use Likert Scale* **to measure occurrence)**

Representations

Question 9. While working on the problems in this class, to what degree did problem solving require understanding mathematical ideas presented in multiple ways: symbols, graphs, tables, pictures, letters, numbers, and other mathematical presentations?

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

(Frequency of Use Likert Scale **to measure occurrence)**

Question 10. How challenging was it to understand the use of different mathematical presentations to solve problems?

1 - Not challenging at all, 2 - Moderate level of challenge, 3 - Perfect level of challenge to keep it interesting, 4 - Higher level of challenge. Took a lot of work, but I solved it, 5 - Too challenging, could not solve.

(Level of Difficulty Likert Scale **to measure challenge)**

Crosswalk between (NCTM) Process Standards, Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners, and their most critical skills and practices adapted into Student Classroom Work Rating Scale questions for gifted and talented 5-6th grade math students

NCTM Process Standards	Common Core Standards for Mathematical Practices adjusted for Gifted and Advanced Learners	Student Classroom Work Rating Scale questions
Problem Solving	1.Make sense of problems and persevere in solving them 7. Look for and make use of structure	**Question 1.** Think of all the tasks worked on in the classroom. Did most tasks/problems solving require creating and following a strategy?

		Question 2. On the occasions you used a strategy to solve a problem, how difficult was it to develop a strategy?
Reasoning and Proof	2. Reason abstractly and quantitatively 6. Attend to precision 8. Look for and express regularity in repeated reasoning 9. Solve problems in novel ways and pose new mathematical questions of interest to investigate.	**Question 3.** Think about all the reasoning and proofs you had to complete for the work in class. Did obtaining the correct answer require 1. analyzing patterns, structure 2. making connections between parts of the problem? **Question 4.** Think about all the reasoning and proofs you had to complete for the work in class. How often did you or another student at your table come up with new, creative, unusual, or different ways to solve a problem?
Communicati on	3. Construct viable arguments and critique the reasoning of others	**Question 7.** Think of all the work you completed in class while working at your table as a group or with a partner. Did you engage in conversations with other group members while working on this problem to: • Explore solution ideas • Work together to find mistakes • To better understand the problem • To offer or receive help

Connections	Connects all CCSS Mathematical Practices	**Question 8.** While completing work for this class, did you need to make connections between different areas of math or even other subjects to solve problems?
Representations	5. Use appropriate tools strategically 4. Model with mathematics	**Question 9.** While working on the problems in this class, did problem solving require understanding mathematical ideas presented in multiple ways: symbols, graphs, tables, pictures, letters, numbers, and other mathematical presentations? **Question 10.** How challenging was it to understand the use of different mathematical presentations to solve problems?

APPENDIX C

Teacher's Student Observation Scales

Rate students as an observer using **Direct Observation**

High-inference variable observed: examine the behavior and the turned in work (checking for underlying cognitive and emotional causes -- student is not upset or happy for any other reason than work). **Low-inference variable** with two ordinal values observed using the following signs:

1. *Students acts as a participant*

a) appears to be thinking,

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

b) writes down work

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

c) interacts with their group about the task

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

d) asks teacher questions about the task

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

e) pays attention

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

2. *Student acts as an observer*

a) completes their own work

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

b) copies work of group

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

c) participates in a discussion

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

d) makes suggestions

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

e) asks for help when struggling with a problem

1 – Never, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Every time

APPENDIX D

Achievement Chart 5th grade students

Student's de-identified Code Number	Quarter 1 grade In a regular math class	Quarter 2 grade In a regular math class	Quarter 3 grade In a regular math class	RedBird Math Achievement Ranking	Percentage of correctly completed math work in GATE class	Percentage of attempted Classwork

Achievement Chart 6th grade students

Student's de-identified Code Number	Quarter 1 grade In a regular math class	Quarter 2 grade In a regular math class	Quarter 3 grade In a regular math class	RedBird Math Achievement Ranking	Percentage of correctly completed math work in GATE class	Percentage of attempted Classwork

APPENDIX E

Level of Difficulty Likert Scale to Measure Challenge

Think of a level of challenge you experienced solving this task. Circle your answer.

1 - Not challenging at all

2 - Moderate level of challenge

3 - Perfect level of challenge to keep it interesting

4 - Higher level of challenge. Took a lot of work, but I solved it

5 - Too challenging, could not solve.

APPENDIX F

Internally Designed Mathematics Differentiation System for Gifted 5th and 6th Grade Students

Svetlana Kovalkova-McKenna

Instructional Goals

1. Provide opportunity for acceleration, collaboration, competition, and creativity

a. Accelerate standards and clusters of standards across grade levels and across courses.

b. Vary the pace within learning activities.

c. Encourage creativity by developing open-ended problems

d. Make connections and integrate math across domains

e. Identify themes and concepts within and across domains.

f. Solve problems that relate to global issues

2. Provide motivation to exert effort, get comfortable and learn from mistakes

a. Build complex problems

b. Adopt mastery orientation towards learning

c. Use deliberate questioning techniques to elevate thinking

d. Normalize the amount of effort it takes to be exceptional in mathematics

e. Provide safe place to make mistakes

f. Normalize being comfortable with mistakes and seeing them as a learning opportunity

g. Encourage developing persistence as a vital quality of a mathematician

Learning Goals

a. History of mathematics. By watching excerpts from "The Story of Maths," through classroom discussions, collaborative, and individual work, examine the development of key mathematical ideas throughout the history of mankind and learn how mathematical ideas contributed to the world's science, technology, and culture.

b. Learn about connections between history of science and mathematics and individuals who contributed to the development of both.

c. Strengthen mathematical reasoning (primarily focus on algebraic reasoning), critical thinking, and computational skills through solving puzzles, cognitive tasks, challenging logic, and mathematical problems.

d. Students follow individual learning paths in Stanford University developed software RedBird Math

Content and Pacing Note

Curriculum below is constantly adjusted to serve the needs of individual students. We accelerate or slow down as we need to add materials to better serve students' strengths and interests, as we work to meet our learning and instructional goals. Anyone following or replicating this curriculum is advised to do the same.

Quarter 1	Activities and Materials	Unit Domains	NAGC Gifted Programming Standards
	RedBird Math (Stanford University) 3-4 times weekly during PLT	Individual grade level and unit placement by an adaptive motion engine working in real time.	3.1.1. Educators use local, state, and national content and technology standards to align, expand, enrich, and/or accelerate curriculum and instructional plans. 5.1.5. Educators leverage technology to increase access to high-level programming by providing digital learning options

			and assistive technologies.

	GATE Math weekly pull-out
	
	A. History of Mathematics
	
	1. The Map of Mathematics
	2. Prehistoric Mathematics
	3. Sumerian/Babylonian Mathematics
	4. Egyptian Mathematics
	5. Greek Mathematics
	    1. Pythagoras
	    2. Plato
	6. Hellenistic Mathematics
	    1. Euclid
	    2. Archimedes
	    3. Diophantus
	7. Roman Mathematics
	8. Mayan Mathematics
	9. Chinese Mathematics
	10. Indian Mathematics
	    1. Brahmagupta
	    2. Madhava
	
	B. Collaborative Group Work
	
	1. Geometric Volume Tasks using 3D interlocking blocks
	
	2. Geometric Puzzle Cubes
	
	3. Balance Benders (levels 2-3) puzzles for deductive thinking skills and pre-algebra
	
	4. Balance Math Puzzles (levels 2-3) for algebraic equations and systems of equations
	
	5. Mind Bender Puzzles (levels 4-5) for deductive reasoning and organized analysis skills
	
	6. Math Perplexors (levels D and Expert, grades 7-
		• Operations and Algebraic Thinking
		• Expressions and Equations
		• Geometry
		• Algebra
			1.2.2. Educators assist students with gifts and talents in developing identities consistent with their potential and areas of talent.
			3.1.6. Educators pace instruction based on the learning rates of students with gifts and talents and compact, deepen, and accelerate curriculum as appropriate.
			3.4.2. Educators provide opportunities for students with gifts and talents to explore, develop, or research in existing domain(s) of talent and/or in new areas of interest.
			4.1.4. Educators provide feedback that promotes perseverance and resilience and focuses on effort, on evidence of potential to meet high standards, and on mistakes as learning opportunities.
			4.2.1. Educators provide learning environments for both solitude and social interaction.

	9) for logic development and computational skills 7. Collaborative group work on creating and solving algebraic systems of equations represented as balance puzzles 8. Drop everything and read Math Books Day to introduce students to the classroom's math and science library and give them time and opportunity to explore it.		
Quarter 2			
	RedBird Math (Stanford University) 3-4 times weekly during PLT	Individual grade level and unit placement by an adaptive motion engine working in real time.	3.1.1., 5.1.5.
	GATE Math weekly pull-out ***A. History of Mathematics*** 1. Islamic Mathematics 1. Al-Khwarizmi 2. Medieval European Mathematics 1. Fibonacci 3. 16th Century Mathematics 1. Tartaglia, Cardano and Ferrari 4. 17th Century Mathematics 1. Descartes 2. Fermat 3. Pascal 4. Newton 5. Leibniz ***B. Collaborative Group Work***	• Operations and Algebraic Thinking • Expressions and Equations • Geometry • Algebra	1.2.2. Educators assist students with gifts and talents in developing identities consistent with their potential and areas of talent. 3.1.6. Educators pace instruction based on the learning rates of students with gifts and talents and compact, deepen, and accelerate curriculum as appropriate. 3.4.2. Educators provide opportunities for students with gifts and talents to explore, develop,

	1. Geometric Puzzle Cubes 2. Balance Benders (levels 2-3) puzzles for deductive thinking skills and pre-algebra 3. Balance Math Puzzles (levels 2-3) for algebraic equations and systems of equations 4. Mind Bender Puzzles (levels 4-5) for deductive reasoning and organized analysis skills 5. Math Perplexors (levels D and Expert, grades 7-9) for logic development and computational skills 6. Collaborative group work on creating and solving algebraic systems of equations represented as balance puzzles 7. Drop everything and read Math Books Day to introduce students to the classroom's math and science library and give them time and opportunity to explore it. 8. Mensa for Kids and Mathematical Games week. Students solve secret codes, number puzzles, word puzzles, math puzzles, geometric 3D puzzles, play mathematical games with prime numbers, operations with integers, algebraic expressions, and operations with rational numbers.		or research in existing domain(s) of talent and/or in new areas of interest. 4.1.4. Educators provide feedback that promotes perseverance and resilience and focuses on effort, on evidence of potential to meet high standards, and on mistakes as learning opportunities. 4.2.1. Educators provide learning environments for both solitude and social interaction.
Quarter 3			
	RedBird Math (Stanford University) 3-4 times weekly during PLT	Individual grade level and unit placement by an adaptive motion engine working in real time.	3.1.1., 5.1.5.

	GATE Math weekly pull-out ***B. History of Mathematics*** 1. 18th Century Mathematics 1. Bernoulli Brothers 2. Euler 2. 19th Century Mathematics 1. Galois 2. Gauss 3. Bolyai and Lobachevsky 4. Riemann 5. Boole 6. Cantor 7. Poincaré 3. 20th Century Mathematics 1. Hardy and Ramanujan 2. Russell and Whitehead 3. Hilbert 4. Gödel 5. Turing 6. Weil 7. Cohen 8. Robinson and Matiyasevich ***B. Collaborative Group Work*** 1. Geometric Puzzle Cubes 2. Balance Benders (levels 2-3) puzzles for deductive thinking skills and pre-algebra 3. Balance Math Puzzles (levels 2-3) for algebraic equations and systems of equations 4. Balance Math teaches Algebra 5. Mind Bender Puzzles (levels 4-5) for deductive reasoning and organized analysis skills 6. Math Perplexors (levels D and Expert, grades 7-9) for logic development and computational skills	• Operations and Algebraic Thinking • Expressions and Equations • Geometry • Algebra	1.2.2. Educators assist students with gifts and talents in developing identities consistent with their potential and areas of talent. 3.1.6. Educators pace instruction based on the learning rates of students with gifts and talents and compact, deepen, and accelerate curriculum as appropriate. 3.4.2. Educators provide opportunities for students with gifts and talents to explore, develop, or research in existing domain(s) of talent and/or in new areas of interest. 4.1.4. Educators provide feedback that promotes perseverance and resilience and focuses on effort, on evidence of potential to meet high standards, and on mistakes as learning opportunities. 4.2.1. Educators provide learning environments for both solitude and social interaction.

	7. Collaborative work solving and analyzing Math Olympiad problems 8. Mathematical challenge problems and logic puzzles. 9. Drop everything and read Math Books Day to give students an opportunity to explore the classroom's math and science library. 10. Mensa for Kids and Mathematical Games week. Students solve secret codes, number puzzles, word puzzles, math puzzles, geometric 3D puzzles, play mathematical games with prime numbers, operations with integers, algebraic expressions, and operations with rational numbers.		
Quarter 4			
	RedBird Math (Stanford University) 3-4 times weekly during PLT	Individual grade level and unit placement by an adaptive motion engine working in real time.	3.1.1., 5.1.5.
	GATE Math weekly pull-out 1. Create presentations about famous mathematicians and their discoveries - group or individual projects with a focus on reading, writing, and research. 2. Geometric Puzzle Cubes 3. Balance Benders puzzles for deductive thinking skills and pre-algebra 4. Balance Math Puzzles for algebraic equations and systems of equations	• Operations and Algebraic Thinking • Expressions and Equations • Geometry • Algebra	1.2.2. Educators assist students with gifts and talents in developing identities consistent with their potential and areas of talent. 3.1.6. Educators pace instruction based on the learning rates of students with gifts and talents and compact, deepen, and accelerate

	5. Balance Math teaches Algebra 6. Mind Bender Puzzles for deductive reasoning and organized analysis skills 7. Math Perplexors (levels D and Expert, grades 7-9) for logic development and computational skills 8. Collaborative work solving and analyzing Math Olympiad problems 9. Drop everything and read Math Books Day to give students an opportunity to explore the classroom's math and science library. 10. Mensa for Kids and Mathematical Games week. Students solve secret codes, number puzzles, word puzzles, math puzzles, geometric 3D puzzles, play mathematical games with prime numbers, operations with integers, algebraic expressions, and operations with rational numbers. 11. Mathematical challenge problems and logic puzzles.		curriculum as appropriate. 3.4.2. Educators provide opportunities for students with gifts and talents to explore, develop, or research in existing domain(s) of talent and/or in new areas of interest. 4.1.4. Educators provide feedback that promotes perseverance and resilience and focuses on effort, on evidence of potential to meet high standards, and on mistakes as learning opportunities. 4.2.1. Educators provide learning environments for both solitude and social interaction.

Curriculum Resources

Educational Software

REDBIRD Mathematics. (2022, March 28). *REDBIRD Mathematics*. McGraw Hill Education. Retrieved March 28, 2022 from [Personalized Learning for Math | Redbird | McGraw Hill (mheducation.com).] RedBird Math - Stanford University developed Math software. Students login through Clever using McGraw Hill App.

Educational Materials

The Critical Thinking Co. resources recommended by MNPS Office of Gifted and Talented:

The Critical Thinking Co. (March 28, 2022). The Critical Thinking Co. Retrieved March 28, 2022 from https://www.criticalthinking.com/?gclid=CjwKCAjwo8-SBhAlEiwAopc9W5fsIsbNqTP6b56rYi6tFAjuHupJGf7Dt9PmlbvWAj_AqS1KMbo5YhoCvWUQAvD_BwE

a. *Balance Math and More* and *Balance Bender* series, math workbooks, written by Robert Femiano, public school teacher, 2001-2002 Presidential Award for Excellence in Mathematics and Science Teaching Winner, an author of *Quick Thinks Math, Balance Math & More*, and a contributor to National Council for Teachers of Mathematics journal.

Femiano, R. (2010). *Balance math & more Level 1 workbook - Sharpening critical thinking, computational, & algebraic reasoning skills (Grades 2–5)*. The Critical Thinking Co.

Femiano, R., & Slyter, S. (2010). *Balance math and more Level 2 - Sharpening critical thinking, computational, and algebraic reasoning skills (Grades 4–12)*. CRITICAL THINKING PRESS.

Femiano, R. (2022b). *Balance math teaches algebra workbook - Sharpening critical thinking & algebraic reasoning skills (Grades 4–12)*. The Critical Thinking Co.

Femiano, R., & Slyter, S. (2010). *Balance math and more Level 3 - Sharpening critical thinking, computational, and algebraic reasoning skills (Grades 6–12)*. CRITICAL THINKING PRESS.

Femiano, R. (2010). *Balance benders, Level 1*. The Critical Thinking.

Femiano, R. (2010). *Balance benders, Level 2*. The Critical Thinking.

Femiano, R. (2010). *Balance benders, Level 3*. The Critical Thinking.

b. *Mind Benders* series, math workbooks, written by Anita Harnadek, contributing author of Critical Thinking Co, an author of 62 books on problem solving, mathematical education, logic, and reasoning.

Harnadek, A. (2010). *Mind Benders Level 3*. Critical Thinking Company.

Harnadek, A. (2010). *Mind Benders Level 4*. Critical Thinking Company.

Harnadek, A. (2010). *Mind Benders Level 5*. Critical Thinking Company.

The MindWare resources recommended by MNPS Office of Gifted and Talented:

MindWare. (March 28, 2022). MindWare. Retrieved March 28, 2022 from https://www.mindware.orientaltrading.com/?source=google&ms=search&cm_mmc=GoogleBrand-_-319458763-_-20811127363-_-mindware&cm_mmca2=Brand&cm_mmca4=kwd-115155584&cm_mmca8=e&cm_mmca11=mindware&gclid=CjwKCAjwo8-SBhAlEiwAopc9W-ybTGQGdjj6k0WH9DEg_UtT7QsFv6dfA_ZAsBTToqzC28rm6D7m8hoC2FcQAvD_BwE

***Perplexors* series, deductive logic puzzles from MindWare by Greg Gottstein recommended by MNPS Office of Gifted and Talented:**

Gottstein, G. (2022). *Math Perplexors: Deductive logic puzzles, Level D.* MindWare.

Gottstein, G. (2022). *Math Perplexors: Deductive logic puzzles, Level C*. MindWare.

Gottstein, G. (2022). *Math Perplexors: Deductive logic puzzles, Expert Level* (Expert Level ed.). MindWare.

UK and US Math Olympiad materials for middle and high school students:

Junior Mathematical Olympiad archive. (March 28, 2022). UK Mathematics Trust. Retrieved March 28, 2022 from https://www.ukmt.org.uk/competitions/solo/junior-mathematical-olympiad/archive

Math Olympiads for Elementary and Middle Schools – MOEMS. (March 28, 2022). Math Olympiads for Elementary and Middle Schools – MOEMS. Retrieved March 28, 2022 from https://moems.org/

Mensa math materials for students: books, puzzles, games, online resources

Mensa for Kids. (March 28, 2022). Mensa for Kids. Retrieved March 28, 2022 from https://www.mensaforkids.org/

Additional Math Curriculum Resources

DK. (2019). *The math book: Big ideas simply explained* (Illustrated ed.). DK.

Boaler, J., Munson, J., & Williams, C. (2018). *Mindset mathematics: Visualizing and investigating big ideas, Grade 5*. Wiley.

Boaler, J., Munson, J., & Williams, C. (2019a). *Mindset mathematics: Visualizing and investigating big ideas, Grade 6* (1st ed.). Jossey-Bass.

Boaler, J., Munson, J., & Williams, C. (2019). *Mindset mathematics: Visualizing and investigating big ideas, Grade 7* (1st ed.). Jossey-Bass.

History of Mathematics and Science

Berlinghoff, W. P., & Gouvea, F. Q. (2019). *Math Through the Ages: A Gentle History for Teachers and Others (Dover Books on Mathematics)* (Illustrated ed.). Dover Publications.

du Sautoy, M., & Audio, B. D. (2020). *A brief history of mathematics: Complete series*. BBC Digital Audio.

Gifford, C., & Young, M. (2021). *A quick history of math: From counting cavemen to computers (Quick Histories)*. Wide Eyed Editions.

Hakim, J. (2016). *The story of science: Aristotle leads the way*. Smithsonian.

Hakim, J. (2016b). *The story of science: Newton at the center*. Smithsonian.

Hakim, J. (2007). *The story of science: Einstein adds a new dimension* (Illustrated ed.). Smithsonian Books.

Jackson, T. (2017). *Mathematics: An Illustrated History of Numbers (Ponderables: 100 Breakthroughs that Changed History) Revised and Updated Edition (100 Ponderables)* (Revised, Updated ed.). Shelter Harbor Press.

Pickover, C. A. (2012). *The Math Book: From Pythagoras to the 57th Dimension, 250 Milestones in the History of Mathematics (Sterling Milestones)*. Sterling.

Additional Puzzles and Challenging Problems

Clarke, B. R., & Collinet, R. (2003). *Challenging Logic Puzzles (Official Mensa puzzle book)*. Sterling

Gardner, M. (2016). *My Best Mathematical and Logic Puzzles (Dover Recreational Math)* (First Thus Used ed.). Dover Publications, Incorporated.

Ryder, S. P. (2021). *Puzzle Baron Logic Puzzles, Volume 1–3*. Generic.

Saunders, E. (2019). *IQ Puzzles (192pp for B&N)*. Arcturus.

Trust, M. T. U. K. (2019). *The ultimate mathematical challenge: Over 365 puzzles to test your wits and excite your mind* (edition ed.). HarperCollins.

Mathematics, Geometry, STEM, and other Cognitive Games

Be Amaysing. (*2020). Absolute Zero* [Game]. Be Amaysing.

EAI Education. (2014). *Math Stacks Integers Game: Grades 6-8* [Game]. EAI Education.

EAI Education. (2014). *Math Stacks One-Step Algebra Game:Grades 6-8* [Game]. EAI Education.

Edupress. (2012). *Mathological Liar Game, Grade 6* [Game]. Teacher Created Resources OS.

Conceptual Math Media. (2008). *Equate. The Equation Thinking Game* [Game]. Conceptual Math Media.

Learning Advantage. (2010). *Quizmo integers multiplication and division* [Game]. Learning Advantage.

Learning Advantage. (2010). *Quizmo integers addition and subtraction* [Game]. Learning Advantage.

Learning Advantage. (2010). *Quizmo geometry* [Game]. Learning Advantage.

Learning Advantage. (2010). *Equivalent fractions domino* [Game]. Learning Advantage.

Math for Love. (2017). *Prime Climb* [Game]. Math for Love.

Mensa Mighty Mind Bender Card Game Series: number, vocabulary, logic, word, mind mazes, brain teasers, secret codes.

2021 Mensa Select® Winners Announced. (March 28, 2022). American Mensa. Retrieved March 28, 2022 from https://www.us.mensa.org/newsroom/press-releases/2021-mensa-select-winners-announced/

Mensa Recommended Games. (March 28, 2022). American Mensa. Retrieved March 28, 2022 from https://www.mensamindgames.com/about/mensa-recommended-games/

Quiroga, H., & Reed, J. (1997). *Mensa Brain Bafflers for Kids* [Game]. British Mensa Limited.

Teacher Created Resources. (2010). *I have…Who has? Math grades 5-6* [Game]. Teacher Created Materials.

The Master Theorem Games. *(2019). Proof!* [Game]. The Master Theorem Games.

Staff, C. B. (1999). *Mensa: Mighty mind benders:75 number puzzles* [Game]. Chronicle Books.

Staff, C. B. (1999b). *Mensa: Mighty Mind Benders:75 Word Puzzles* [Game]. Chronicle Books.

Video Materials

1. *The Map of Mathematics*. (2017, February 1). YouTube. Retrieved March 28, 2022 from https://www.youtube.com/watch?app=desktop&v=OmJ-4B-mS-Y&feature=youtu.be

   The Map of Mathematics. The entire field of mathematics summarized in a single map!

This shows how pure mathematics and applied mathematics relate to each other and all of the sub-topics they are made from. Made by Dominic Walliman PhD experimental quantum physicist and author of Professor Astro Cat science books for children.

2. Du Sautoy, M. (Director). (2008). *The story of Maths.* [Film]. Open University & BBC. Excerpts from "The Story of Maths" as they align with corresponding math materials, representing the story of mathematics from prehistory to modern day.

   The Story of Maths is a four-part British television series outlining aspects of the history of mathematics. The material was written and presented by University of Oxford professor Marcus du Sautoy. The series comprised four programmes respectively titled: *The Language of the Universe*; *The Genius of the East*; *The Frontiers of Space*; and *To Infinity and Beyond*. Marcus du Satoy examines the development of key mathematical ideas and shows how mathematical ideas underpin the world's science, technology, and culture.

3. BBC. (Director). (2013). *The joy of Logic* [Film]. BBC.

Excerpts from “The Joy of Logic” BBC Select. Wielding the same wit and wisdom, animation and gleeful nerdery as its predecessors, this film journeys from Aristotle to Alice in Wonderland, sci-fi to supercomputers to tell the fascinating story of the quest for certainty and the fundamentals of sound reasoning itself.

Dave Cliff, professor of computer science and engineering at Bristol University, is no abstract theoretician. 15 years ago, he combined logic and a bit of math to write one of the first computer programs to outperform humans at trading stocks and shares. Giving away the software for free, he says, was not his most logical move...

Classroom Library

Bellos, A. (2010). *Here's looking at Euclid: A surprising excursion through the astonishing world of math* (1st ed.). Free Press.

Benjamin, A. (2016). *The magic of math: Solving for x and figuring out why* (Reprint ed.). Basic Books.

Benjamin, A., Shermer, M., & Nye, B. (2006). *Secrets of mental math: The mathemagician's guide to lightning calculation and amazing math tricks* (Illustrated ed.). Crown.

Bowkett, S. (2013). *Archidoodle: The architect's activity book* (Illustrated ed.). Laurence King Publishing.

Burns, M. (1982). *Brown paper school book: Math for smarty pants*. Adfo Books.

Bynum, W. (2013). *A little history of science* (Illustrated ed.). Yale University Press.

DALE SEYMOUR PUBLICATIONS. (1994). *Mathematicians are people, too: Stories from the lives of great mathematicians* (0 ed.). DALE SEYMOUR PUBLICATIONS. (Book 1)

de Klerk, J., & de Klerk, J. (2011). *Math dictionary*.Van Haren Publishing.

DK. (2020). *Beginner's step-by-step coding course: Learn computer programming the easy way*. DK.

DK. (2016). *How to be good at math: Your brilliant brain and how to train it* (Illustrated ed.). DK Children.

Flansburg, S. (1994). *Math magic by Flansburg*. Perennial Currents.

Fitzgerald, T. R. (2016). *Math dictionary for kids*. Amsterdam University Press.

Frieder, D., & Smith, S. (2002). *Get wise!* Thomson/Peterson's.

Gale, H., & Skitt, C. (2000). *Number puzzles for kids (Mensa)*. Scholastic Paperbacks.

Gardner, M. (2021). *The colossal book of short puzzles and problems*. W. W. Norton & Company.

Gifford, C., & Young, M. (2021). *A quick history of maths*. Wide Eyed Editions.

Glenn, J., Larsen, E. F., Leone, T., Reusch, M., Kasunick, H., & Frauenfelder, M. (2012). *Unbored: The essential field guide to serious fun* (1st ed.). Bloomsbury USA.

Hackett, C. (2018). *The big book of maker skills: Tools & techniques for building great tech projects* (Reprint ed.). Weldon Owen.

Hakim, J. (2016). *The story of science: Aristotle leads the way*. Smithsonian.

Hakim, J. (2016b). *The story of science: Newton at the center*. Smithsonian.

Hakim, J. (2007). *The story of science: Einstein adds a new dimension* (Illustrated ed.). Smithsonian Books.

Henderson, G. L. (1974). *Let's play games in metrics: 177 objective-associated games and activities*. National Textbook Co.

Jackson, T. (2017). *Mathematics: An illustrated history of numbers (Ponderables:100 breakthroughs thatcChanged history) Revised and updated edition (100 Ponderables)* (Revised, Updated ed.). Shelter Harbor Press.

Julius, E. H. (1992). *Rapid math tricks & tips: 30 days to number power* (1st ed.).Wiley.

Kushner, M. (2015). *The future of architecture in 100 buildings (TED Books)* (Later prt. ed.). Simon & Schuster/ TED.

Large, T. (2021). *Illustrated dictionary of maths* (New edition). Usborne Books.

LearningExpress, LLC. (2012). *501 math word problems (501 Series)* (3rd ed.). LearningExpress, Llc.

Learning Express Llc. (2012). *501 geometry questions (501 Series)* (2nd ed.). LearningExpress, Llc.

Macaulay, D. (2016). *The way things work now* (Illustrated ed.). HMH Books for Young Readers.

McKellar, D. (2021). *Kiss my math by McKellar*. Hudson Street Press.

McKellar, D. (2008). *Math doesn't suck: How to survive middle school math without losing your mind or breaking a nail* (Reprint ed.). Plume.

McKellar, D. (2011). *Hot X: Algebra exposed!* (Illustrated ed.). Plume.

McKellar, D. (2013). *Girls get curves: Geometry takes shape* (Illustrated ed.). Plume.

Miller, M., Lee, M. (2001). *40 fabulous math mysteries kids can't resist [40 FABULOUS MATH MYSTERIES KID][Paperback]*. ScholasticProfessionalBooks.

Müller, R. (1990). *The great book of math teasers* (5th or later Edition). Sterling.

Parsons, P., & Dixon, G. (2020). *Instant mathematics*. Amsterdam University Press.

Pickover, C. A. (2012). *The math book: From Pythagoras to the 57th dimension, 250 milestones in the history of mathematics (Sterling Milestones)*. Sterling.

Publishing, W., Newton, O., & Peterson, A. (2018). *Everything you need to ace math in one big fat notebook: The complete middle school study guide (Big Fat Notebooks)* (Study Guide ed.). Workman Publishing Company.

Publishing, W., & Wang, J. (2021). *Everything you need to ace pre-Algebra and Algebra I in one big fat notebook (Big Fat Notebooks)*. Workman Publishing Company.

Publishing, W., & Smith, G. (2020). *Everything you need to ace Computer Science and Coding in one big fat notebook: The complete middle school study guide (Big Fat Notebooks)* (Illustrated ed.). Workman Publishing Company.

Quinlan, S. E. (2010). *The case of the monkeys that fell from the trees: And other mysteries in tropical nature* (1st ed.). Boyds Mills Press.

Quinlan, S. E., & Dewey, J. (1999). *The case of the mummified pigs, and other mysteries in nature* (Complete Numbers Starting with 1, 1st Ed). Boyds Mills Press.

Reimer, W., & Reimer, W. (1990). *Mathematicians are people, too*. Dale Seymour Publications. (Book 2)

Snider, A. J. (1968). *Numbers and discoveries (The Home adventure library)*. Southwestern Co.

Staff, D. K. P. & Dorling Kindersley Limited. (2019). *Help your kids with Math, Science, and Language Arts*. DK PUB.

Sticker, H. (2021). *How to calculate quickly (The art of calculation)* (reprint ed.). Dover Publications.

Stockley, C., Oxlade, C., Wertheim, J., & Rogers, K. (2007). *The Usborne illustrated dictionary of Science (Usborne Illustrated Dictionaries)* (Revised ed.). Usborne Pub Ltd.

Wertheim, J., Stockley, C., Johnson, F., Oxlade, C., & Rogers, K. (2011). *Illustrated dictionary of Physics*. Usborne.

Wheater, C. C., & Slavin, S. (2022). *All the math you'll ever need: A self-teaching guide (Wiley Self-Teaching Guides)* (3rd ed.). Jossey-Bass.

Yoder, N., & Yoder, N. (2010). *65 short mysteries you solve with math!* Science, Naturally!

Zaccaro, E. (2005). *Challenge math: For the elementary and middle school student* (0 ed.). Hickory Grove Press.

APPENDIX G

INFORMED CONSENT DOCUMENT

Project Title: The Impact of an Internally-designed Mathematics Differentiation System on Gifted and Talented 5th and 6th Grade Students

Investigator: Svetlana Kovalkova-McKenna, WKU Graduate Education Department, Gifted Education, svetlana.kovalkova-mckenna@mnps.org

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** This study will focus on researching the impact of an internally designed mathematics differentiation system on gifted and talented 5th and 6th grade students. The purpose of this study will be to research the impact an internally-designed mathematics differentiation system has on gifted and talented 5th and 6th grade students' feeling of joy (social-emotional aspect) in class, feeling challenged (productive struggle), perseverance (ability to complete complex tasks), and achievement (grades, achievement ratings).

Research Question(s): This study will be guided by the following research questions:

1. Main question: What is the impact of an internally-designed mathematics differentiation system on gifted and talented 5th and 6th grade students?
   Sub questions:
   How are students impacted in regard to:
   1) joy (social-emotional aspect),
   2) feeling challenged (productive struggle),
   3) perseverance (ability to complete complex tasks),
   4) and achievement (grades in math and percentage of successfully completed tasks).

Data Collection Summary: Data will be collected through student questionnaires (surveys), teacher observations, and de-identified student data from student records and classwork.

2. **Explanation of Procedures:** The study will be part of regular everyday work in GATE math pull-out class. All students are expected to participate fully in all routine classroom activities; there will be no extracurricular activities. Students who will participate in a study will do the exact same work as students who will not participate in a study. All students will be expected to fill out two brief surveys (about 5 minutes each) and to rate twenty classroom tasks (less than a minute per task). Students who do not participate in a study will not have their data analyzed in a research paper. Students who participate in a study will have their data collected to be reported as part of a group; individual student names will not be used. Students who do not participate in research will have their data evaluated by the teacher for internal classroom data purposes only.

3. **Discomfort and Risks:** There are no foreseeable risks or discomforts to participants as a result of their participation in this study. The risks associated with participation in this research are minimal and no more than that encountered in everyday activities.

WKU IRB# 22-112
Approved: 11/23/2021
End Date: 11/01/2022
Full Board Review

4. **Benefits:** The anticipated participant benefits may include understanding that teachers research and evaluate instructional strategies, programs, and materials used in a gifted and talented classroom to improve students' outcomes. Another anticipated benefit is teacher's understanding of the impact the internally-designed mathematics differentiation system has on gifted and talented 5th and 6th grade students and collaborating with other teachers of gifted and talented students to improve the program to better serve the students. The anticipated benefits to education stakeholders are such as the teacher will benefit from analyzing the data in graduate study research by becoming a better educational practitioner in a classroom.

5. **Confidentiality:** All data will be kept in a secure manner. Publications or presentations related to this study will not include identifiable references to subjects' identities. Records will be viewed, stored, and maintained in private, secure files only accessible by the P.I. and advising faculty for three years following the study, after which time they will be destroyed.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future gifted and talented services or program participation you may be entitled to from the school. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

____ ________________

Parent/Legal Guardian Signature (consent) Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Robin Pyles, Human Protections Administrator
TELEPHONE: (270) 745-3360

INSTITUTIONAL REVIEW BOARD WKU APPROVED

WKU IRB# 22-112
Approved: 11/23/2021
End Date: 11/01/2022
Full Board Review
Original: 11/23/2021

APPENDIX H

INFORMED ASSENT DOCUMENT

Project Title: The Impact of an Internally-designed Mathematics Differentiation System on Gifted and Talented 5th and 6th Grade Students

Investigator: Svetlana Kovalkova-McKenna, WKU Graduate Education Department, Gifted Education, svetlana.kovalkova-mckenna@mnps.org

You are being asked to take part in a research project.

What is the purpose of this research?

This research is being done to find out more about how JT Moore GATE Math program affects students'

- feeling of joy (social-emotional aspect) in class,
- feeling challenged (productive struggle),
- perseverance (ability to complete complex tasks),
- achievement (grades, achievement ratings).

Important things to know…

- You get to decide if you want to take part.
- You can say 'No' or you can say 'Yes'.
- No one will be upset if you say 'No'.
- If you say 'Yes', you can always say 'No' later.
- You can say 'No' at any time.

What would happen if I joined this research?

- Students who take part in the study will complete the same work as students who do not take part in the study.
- Students who decide to take part in a study will be asked to complete two surveys/questionnaires about the work we do in class (5 - 10 minutes each) and to rate the challenge level of 20 tasks we complete in class (1 question for each task).

Could the research help me?

Collecting and analyzing the data from this research could help the researcher improve the gifted math program to better serve gifted and talented students at our school and other schools in our district.

What else should I know about this research?

In order for you to agree to participate in this study, your parent/guardian has to agree for you to take part in it first.

Is there anything else?

If you want to be in the research after we talk, please write your name below. We will write our name too. This shows we talked about the research and that you want to take part.

Name of Participant ____

(To be written by child/adolescent)

Printed Name of Researcher

__Svetlana Kovalkova-McKenna_______________________________________

Signature of Researcher

____

Date ____________________________

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
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Type of document: ['Specialist Project']

Title: THE IMPACT OF INTERNALLY DESIGNED MATHEMATICS DIFFERENTIATION SYSTEM ON GIFTED AND TALENTED 5TH AND 6TH GRADE STUDENTS

Keywords (3-5 keywords not included in the title that uniquely describe content): gifted education, mathematically gifted, middle school students, gifted services

Committee Chair: Janett Tassell

Additional Committee Members: Julia Roberts, Natasha Gerstenschlager

Select 3-5 TopSCHOLAR® disciplines for indexing your research topic in TopSCHOLAR®: Education: Gifted Education, Education: Science and Mathematics Education, Education: Special Education and Teaching, Education: Teacher Education and Professional Development, Education: Educational Methods,

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