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Increasing Motivation Toward Math in a Montessori Lower Elementary Classroom

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Abstract

This study investigated how the introduction of math-based games influences children's motivation to practice math. It was conducted in a Lower Elementary Montessori classroom, serving first through third grade and twenty-one students participated. The students played one of three games every day throughout the study. Their motivation toward math was tracked through observational data and their daily work journals. Additionally, each participant answered pre and post intervention questions to ascertain their mindset toward math. The data shows that the intervention had minimal impact on the students' motivation toward math, although some students did increase the frequency of their math practice. In the future, students who display a lack of motivation toward math would benefit from consistent one-on-one meetings to address their motivation.

Keywords: Montessori, elementary, math, motivation

Introduction

Small groups of children are seated throughout the classroom, hard at work on a wide variety of projects. One group is building a model of the Himalayas, another group is writing a list of words with suffixes and another group is solving a long division problem using manipulative, concrete materials. This is an average morning in a Montessori elementary classroom. The children are expected to independently choose their work as well as their work partners, moving from one activity to the next throughout the morning. However, with this freedom comes the responsibility of varying the types of work. When the children do not choose a variety of work independently, the guide, or teacher, must ensure that the children are working in all subject areas. This research addresses an underrepresentation of math in the work choices of six to nine year old children in a Lower Elementary classroom.

Throughout the day, the teacher gives lessons to small groups of children and they are expected to follow-up from that lesson, practicing the new skill or deepening their understanding of the topic while the teacher moves on to teach the next lesson. Children have the opportunity to exercise their creativity when it comes to following up and the possibilities are nearly endless. Some children may decide to embark on a written research project while others might decide to build a model of the concept or design a board game relating to the topic. However, most math lessons are presented using concrete, manipulative materials and while there is some room for creativity, the follow up work from these lessons tends to be continued practice with the material.

The Montessori math materials are often game-like in nature and require cooperation and teamwork from a group of children. They are designed to provide a deeper understanding of the algorithm for the particular mathematical concept and, with sufficient practice, the children are able to independently discover the reasons behind long division and long multiplication, for example. However, elementary children want variety in their work. Rarely will they eagerly repeat the same procedure with the same material for long periods of time. To provide that diversity, long multiplication can be approached using no fewer than five different materials and each new material can reignite the children's excitement for multiplication.

Even with the diversity of materials, it can be difficult to sustain the children's interest for long enough for them to internalize the concept. When they receive a new math lesson, many children practice with the material one or two times and then stop choosing the material. When they are reminded to practice again, the children have often forgotten how to use the material and as a result, these children often receive the same math lesson multiple times, inhibiting their ability to move on to new concepts.

While there are myriad ways to ensure that children are practicing math lessons consistently, many of them restrict the children's ability to choose their own work and potentially inhibit any existing excitement and joy for math. In some Montessori classrooms, children are expected to complete a certain number of practice problems after each new math lesson. In other classrooms, children must practice math every day, which implicitly prioritizes math over other types of work. Both of these methods introduce math as a subject that should be checked off a to-do list rather than an integrated part of learning that can apply to many different subject areas.

As I was designing this research project, I wanted to find a way to encourage the children in my classroom to practice math without enforcing stringent guidelines, such as a particular number of problems or daily practice. Instead, I decided to appeal to the developmental characteristics of elementary children. According to Montessori theory, from the ages of six to twelve, children are particularly driven by their social relationships (Montessori, 1989). Relying on these social needs, I introduced daily math games focusing on basic math facts, place value and multiples. These games include the whole class and thrive through mass participation. My research question is: How will playing math and number-oriented games affect the children's intrinsic motivation to practice math independently?

Theoretical Framework

This study is informed by Dweck's theory of growth mindset in conjunction with Dr. Montessori's theory of the four planes of development. Dweck's theory posits that children are influenced by their mindset and that it changes their approach to learning new information (Dweck, 2006). Dr. Montessori's theory of the four planes of development emphasizes the social nature of elementary children, emphasizing their tendency to be motivated to try new academic pursuits by their peers (Montessori, 2007). Together, these two theories illuminate the primary factors affecting children's motivation toward math in a Montessori elementary classroom.

Dweck's theory of growth mindset suggests that people's ability to learn new skills is impacted by their mindset, which can either be a growth mindset or a fixed mindset. A growth mindset is the belief that effort affects performance and intelligence. People with a growth mindset believe that, if they put forth effort towards a task, over time their performance will improve, and they will develop new skills (Park, et al., 2016; Haimovitz & Dweck, 2017; Stipek & Gralinski, 1996; Dweck, 2006). A fixed mindset, on the other hand, is the belief that intelligence is a static entity and it is not affected by effort. People with a fixed mindset believe that no matter what they do, they will have the same skills and ability, and their performance will not change (Park, et al., 2016; Haimovitz & Dweck, 2017; Stipek & Gralinski, 1996; Dweck, 2006). The difference between these two mindsets dramatically affects children's motivation to attempt new or difficult tasks in the classroom. Children with a growth mindset generally show greater willingness to attempt a new, and potentially difficult, task.

From extensive scientific observations, Dr. Montessori developed the theory of the four planes of development. Each plane lasts approximately six years, beginning at birth and continuing until twenty-four years of age. During the second plane of development, from six to twelve years of age, children begin to develop an interest in society, among many other characteristics. They have an innate drive to be social and to understand the social and moral code of their culture. Dr. Montessori states that for elementary children "knowledge and social experience must be acquired at one and the same time" (Montessori, 2007, p. 13). Moreover, elementary children display a developmental need to work with others, not only for companionship but also in "some sort of organized activity." (Montessori, 1989, p. 4). Dr. Montessori goes even further to address this social desire in elementary children through "going out," a process through which the leave the classroom to find out more information about an academic interest, while simultaneously learning how to function appropriately in society. Observations showed it is foolhardy to try and separate the social experience of elementary children from their academic pursuits and rather, social relationships can help to motivate children academically.

Together, these two theories create a holistic understanding of the factors influencing the motivation of children in a Montessori classroom. In Montessori education, abstract mathematical concepts are taught using concrete, manipulative materials, designed to appeal to the child's developmental needs. After the lesson, the children are expected to continue to regularly practice the concept using the material until they have mastered the task. Dweck's theory of a fixed mindset helps to explain why some children may not be motivated to continue to practice after the lesson. If a fixed mindset leads children believe that their skills and ability will not change, regardless of their effort, they will not be motivated to continue to try and learn a new concept.

The emphasis on social relationships in the development of the elementary child adds another layer to their motivation. The interests and motivation of friends and peers can easily sway the children. Often a child who does not continue to practice after a lesson will become motivated if a close friend shows interest. Together, the children work in small groups, correcting each other's mistakes and sharing the work.

In my research, I reliedon the social needs of the elementary children to increase their motivation to practice math. Every day, I played one of three math games with the whole group. They hadto work together to succeed at the games and since elementary children are motivated by social relationships, this group work can motivate them to improve the skills necessary for the game. This study assessed the impact of social, group math games on children's motivation to practice math throughout the school day.

Literature Review

How can educators motivate students to take on challenging tasks and exert continued effort? Relying on the theoretical framework of growth mindset, this review of literature examines the potential factors contributing to intrinsic motivation toward math, exploring the impact of the social nature of elementary children, growth and fixed mindsets, and math anxiety. The literature shows that children are more motivated to continue to exert effort in math class when they have a growth mindset, whereas children with a fixed mindset, or those with math anxiety, are more likely to believe their ability is fixed or become overwhelmed by negative emotions. It is of utmost importance that children are encouraged to adopt a growth mindset early in their elementary education, because the effects of a fixed mindset and math anxiety are only exacerbated with age. The review will also investigate the roles that parents and teachers play in the development of children's mindsets and intrinsic motivation and effects on math achievement.

Impact of Mindset on Math Achievement

Children with a growth mindset are motivated to attempt challenging tasks (Dweck, 2006). When faced with a setback or difficult problem, these children generally exert more effort to master the skill. As a result, their academic achievement improves over time. In one study of seventh graders in a public school, Blackwell, Trzeniewski, and Dweck investigated the relationship between mindset and improvement in math grades over two years (2007). The study found that students who entered junior high school with a growth mindset showed an improvement in their math grades while students with a fixed mindset showed a flat trajectory in their math grades.

Extensive research has been conducted on the positive effects of a growth mindset on academic achievement in older children and adolescents, but little is known about the impact of mindsets on younger elementary children. Park, Tsukayama, Gunderson, Levine and Beilock (2016) conducted a year-long study of first and second-grade students, investigating whether or not mindset affected their achievement in math. The results of the study support the link between a growth mindset and higher academic achievement in math, thereby showing that a growth mindset is essential even at the beginning of elementary school.

Impact of Intrinsic Motivation on Math Achievement

Intrinsic motivation is closely linked with math achievement, although there is disagreement in the literature as to whether or not this relationship is reciprocal. Intrinsic motivation "refers to doing something because it is inherently interesting or enjoyable," while extrinsic motivation "refers to doing something because it leads to a separable outcome" (Ryan & Deci, 2000, p. 55). Froiland, Oros Smith and Hirchert (2012) found that focusing on strategies to increase intrinsic motivation had a direct relationship to children's academic achievement. These strategies include teacher and parent autonomy, effort-based praise delivered with enthusiasm and intrinsic goal setting. Teacher autonomy refers to techniques such as allowing students to take the necessary time to find the answer for themselves, allowing students to make choices about their work partners and emphasizing the reason why the work is relevant for further academic learning (Froiland, Oros, Smith & Hirchert, 2012).

However, in another study of intrinsic motivation and math achievement, Garon-Carrier, Boivin, Guay, Kovas, Dionne, Lemelin and Tremblay (2016) found that academic achievement predicts future intrinsic motivation, but intrinsic motivation does not necessarily predict academic achievement. This finding challenges the idea that intrinsic motivation leads to higher achievement in mathematics, suggesting instead that students must experience the academic achievement first to be intrinsically motivated. The study, therefore, underscores the importance of developing early numeracy skills and emphasizing success early in elementary schools to increase later intrinsic motivation toward math.

Impact of Math Anxiety on Motivation and Math Achievement

Another component of motivation in a math classroom is math anxiety. Math anxiety is a performance-based anxiety disorder that is characterized by "tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002, p. 181). Math anxiety has been primarily studied in older children and adults and has been shown to increase math avoidance and have an adverse effect on mathematical knowledge and performance. Numerical anxiety, test anxiety, worry, and negative reactions are all potential manifestations of math anxiety. While math anxiety has many contributing factors, accumulated negative experiences in math classes are thought to be the primary cause. If children need to build up negative experiences with math in academic settings over a period of time to experience math anxiety, then it stands to reason that first and second-grade students would not experience it, because they have not been formally exposed to math for long enough. (Harari, Vukovic & Bailey, 2013).

However, recent research has shown that children as young as first-grade do experience math anxiety (Harari, Vukovic & Bailey, 2013; Ramirez, Gunderson, Levine & Beilock, 2013). Harari, Vukovic, and Bailey (2013) investigated the presence of numerical anxiety, worry and negative reactions toward math in first and second-grade students. Since the students didn't take tests, the study omitted this aspect of math anxiety. The findings show that numerical anxiety and negative reactions are both measurable in first and second-grade students and that the children's math abilities, specifically computing addition problems, counting and identifying mathematical concepts, were negatively impacted. This finding suggests that the source of math anxiety must come before the child is exposed to formal mathematics in an academic setting. The researchers hypothesized that the cause of math anxiety could come from the family, or from society at large.

Ramirez, Gunderson, Levine and Beilock (2013) also conducted a study investigating math anxiety and first and second-grade students, focusing specifically on the relationship between math anxiety and working memory. The study found that the math achievement of students with high levels of working memory was most impacted by math anxiety, while students with lower levels of working memory were less affected by math anxiety. The researchers theorize that children with high levels of working memory rely on those resources to compute math problems. However, math anxiety uses many of those same resources, therefore leaving children lacking in available working memory. In contrast, children with relatively low working memory have already found other ways to compute the problems and therefore are less affected by math anxiety.

Impact of Adult Expectations on Math Achievement and Mindset

Research shows that the mindset of the teacher also impacts the developing mindset of the students. Teachers with a fixed mindset can communicate this mindset to their students, often in the form of lowering expectations. Rattan, Good, and Dweck (2011) conducted a series of studies with undergraduate and graduate students teaching in mathematics-related fields to assess how the mindset of the teacher is reflected in pedagogical practices. The studies found that when the graduate students were teaching, those holding a fixed mindset were quicker to determine the ability of an undergraduate student and then consequently lowered their expectations for that student. Additionally, the graduate students offered comfort meant to make the student feel better, which instead made the student feel less motivated. Through comforting the students, the graduate students communicated their fixed mindset, expressing their idea that the students with lower ability could not improve. While the comforting remarks were meant to be helpful, instead they backfired, decreasing the motivation of the students and further hampering their ability to learn the required skills.

On the other hand, an intervention conducted by the Silicon Valley Mathematics Initiative during the 2005-2006 school year showed improvement in student's mathematics achievement through increasing expectations for all students (Boaler & Foster, 2013). Teachers participating in the intervention were given professional development to show them how to do away with ability-based groupings in their classes and instead introduce "low floor- high ceiling" problems, which allow students to engage with the problem at varying levels. They were also encouraged to limit assessments based on speed, focusing instead on conceptual understanding (Boaler & Foster, 2013).

Importance of Effort-Based Praise and Mastery-Based Teaching Practices

The type of praise that adults give children can affect the children's mindset starting from a young age. Effort-based praise as early as one to three years old encourages children to adopt a growth mindset (Gunderson et al., 2013). When children are encouraged and praised for their effort (e.g., "You must have worked hard on that."), it motivates them to continue to exert effort, especially as the given tasks become more challenging (Haimovitz & Dweck, 2017; Dweck, 2006). However, when children are given person praise (e.g., "You're so smart."), it leads them to believe that their intelligence is a fixed attribute (Haimovitz & Dweck, 2017; Dweck, 2006). This difference is especially relevant when confronted with difficult tasks. When faced with a potential failure, children who endorse a fixed mindset will often choose an easier task, so that their intelligence is not threatened. If it is only possible to be smart if one succeeds, then failure must mean that one is not intelligent (Haimovitz & Dweck, 2017).

When teachers use mastery-based teaching practices, it also encourages children to endorse a growth mindset (Park, Tsukayama, Gunderson, Levine & Beilock, 2016). Mastery-based teaching practices include such actions as emphasizing conceptual understanding over memorization. Children in mastery-oriented classrooms are more likely to attribute their success to effort and therefore be motivated to attempt challenging tasks (Ames & Archer, 1988). Additionally, when teachers have high expectations and teach all of their students the same challenging and rich material, regardless of perceived mathematical ability, the students' math achievement scores increased (Boaler & Foster, 2013).

The review of the literature shows that fostering a growth mindset, as well as mitigating the effects of math anxiety increases math achievement in early elementary school. Research has shown that effort-based praise, mastery-based teaching techniques, and high expectations all contribute to encouraging children to endorse a growth mindset. It is important for educators to encourage children to adopt a growth mindset early in their education, because the research shows that the negative effects of a fixed mindset, as well as math anxiety, only increase as children get older. Relying on Dr. Montessori's emphasis on the social nature of elementary children, I will implement an intervention using social, whole-group math games with the goal of increasing children's intrinsic motivation to practice math independently early in elementary school.

Methodology

Each day, we played one of three games for between ten and fifteen minutes. Most often, we played the game before lunch although sometimes we played first thing in the morning or just before going home at the end of the day. The three games are Picot Fermi Bagel, Back to Back and Buzz. Picot Fermi Bagel focuses on place value and logical reasoning, Back to Back focuses on basic addition facts and Buzz focuses on multiples. The children already knew how to play Picot Fermi Bagel before the intervention started. I introduced the other two games to the group the first time we played them.

To play Picot Fermi Bagel the leader thinks of a three-digit number and the rest of the class is in charge of trying to guess the leader's number. Children raise their hands to guess a three-digit number and the leader writes the guess down. The leader tells the group which digits are a Fermi, which are a Picot and which are in the Bagel. A Fermi means that the number is the correct number in the correct place. A Picot means that the number is the correct number, but in the wrong place and if the number is in the Bagel, it means that it is not a part of the leader's number at all. The children continue to guess until they have a Fermi Fermi Fermi, which means they have guessed the leader's number.

To play Back to Back, two children stand back to back and each child picks a number between two and nine and writes the number down on a small whiteboard. Another child is the caller. The caller says "numbers up!" and then calls out the sum of the two numbers. Then, each child tries to guess the other child's number first. Whoever loses sits down and another child takes his or her place and the game continues.

To play Buzz, the group starts with a number in mind, for instance three. Then, we go around the circle and each child says a number. If the number is a multiple of three, the child says "buzz" instead of the number. If someone makes a mistake, we begin again at one. The goal is to see how high we can get working together as a group. We played Buzz with multiples of three and multiples of five, though it could be played with any number.

To begin my data collection, I asked the children a series of questions designed to assess their mindset toward math (See Appendix A). I asked each child the same questions though I did often have to rephrase "Math interests me," to "I'm interested in math" so that the children could understand the question. I made sure to ask the children individually so that their friends would not influence their answers. Some children wanted to say "maybe" to one or more of the questions, but I asked them to choose either yes or no. As I went, I recorded each child's answers next to his or her name on a separate sheet of paper. This method of data collection supported my research question, because it showed the child's mindset toward math. If the children already possessed a growth mindset, which would be indicated by a positive response to all three questions, then they would be more likely to be intrinsically motivated to practice new skills in math. I asked these same questions at the end of the intervention to assess whether or not the children's mindset toward math had changed.

After completing these pre-intervention questions, I collected a week of baseline data. In order to collect this information, I used an observation sheet to track math practice throughout the morning and afternoon work period (See Appendix B). I kept a binder full of the observation sheets in a centrally located place in my classroom that was easy to access between lessons. On this observation sheet, I noted the name of the child(ren), whether they chose the material independently or not, and the material they used. The sheet also has a space for the amount of time spent on the task, but I instead used this space to take general notes regarding concentration and the children's ability to use the material independently. I made this change in the first day of data collection, because I realized that I did not consistently observe the exact beginning and end of each work choice. Taking general notes regarding concentration and ability to use the material independently was more relevant, because I could then take notes as to whether or not the children were truly engaging with the material or simply trying to accomplish a task they had been asked to complete. The last column on the sheet asks if the children were working together or alone, but I found that this column was superfluous, because I could tell if they were working together or not based on how many names I wrote down in the first column. I used the observation sheet throughout the morning and afternoon work periods. The morning work period lasts from 8:30-11:30 and the afternoon work period lasts from 1:00-2:40. On Tuesdays, we do not have an afternoon work period, because we have music and PE classes and so no data was collected for this time.

I continued to collect data in the same manner for the next twenty-five school days, recording my data using the observation sheet throughout the morning and afternoon work periods. During the data collection, I was sick one day and we didn't have school for six days and so no data was recorded for these days. The observation sheet supports my research question because it measures the number of times math was practiced each day over the course of the intervention. It also tracks whether the children initiated the math practice or whether an adult initiated it. As the intervention continued, an increase in the children initiating math practice would indicate greater intrinsic motivation.

At the end of this period of twenty-five days, I asked each child the same questions as before the intervention (See Appendix A). Again, I recorded their responses on a separate piece of paper, matching each child's responses to his or her name. By repeating the same questions as before the intervention, I was able to discover whether or not the children's mindsets towards math had changed.

In addition to the observation sheet, I used the children's daily journals as a data source. In these journals, the children record their daily work choices throughout the morning. Most children do not reliably record their work in the afternoon. Additionally, many of them just write "math," and do not make any consistent reference to the amount of time spent on the task. In order to use the journals as a data source, I read through each student's journal at the end of the intervention and tallied the number of times that math was practiced each day for the whole class. Using the journals as a data source supports my research question, because they provide another way to measure the number of times that math is practiced each day. Sometimes a group of children may only have practiced math for a few minutes, or they may have been practicing math just on paper and I may not have seen it in my observations. By using the journals, I am able to strengthen the accuracy of the data recorded on my observation sheet.

Analysis of Data

In my research question, I set out to investigate how playing math games with the whole group would affect children's intrinsic motivation to practice math independently. Figure 1 shows the average number of children practicing math per day over the course of the intervention.

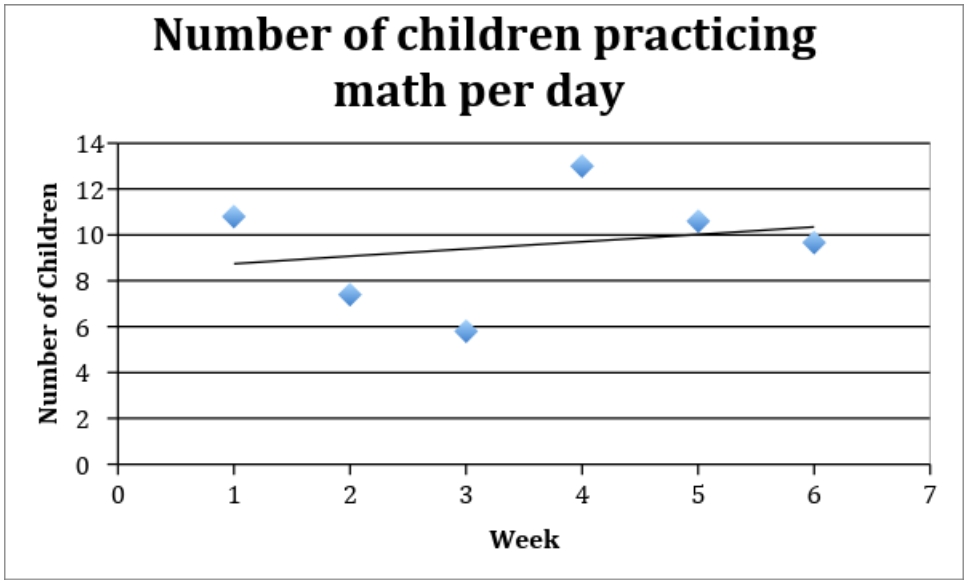

Figure 1: Average number of children practicing math per day

The number of children practicing math each day does not show any consistent change over the course of the intervention. The trend line shows a slight increase from the week of baseline data to the final week, but the individual weeks do not show a consistent trend. This lack of a clear pattern likely points to the influence of other events in the classroom unrelated to the intervention. For instance, at the beginning of week two, there was a parent-child sharing night in the classroom. The children spent all of week one practicing work choices, many of which were math, to show their parents and then after the event, stopped choosing math for the rest of week two. During week three, we returned from a weeklong vacation and many children were excited to get back to work.

One day during this week, no one practiced math in the morning, but everyone was deeply engaged in big, creative projects. That feeling of excitement spread to math through the rest of the week and the number of children practicing math increased. Children expressed understanding that they should choose a variety of work, saying things like “I know I should start with math.” We continued to play the math-oriented games every day, but the data shows that the children’s interest in math was more affected by these other aspects of the classroom schedule.

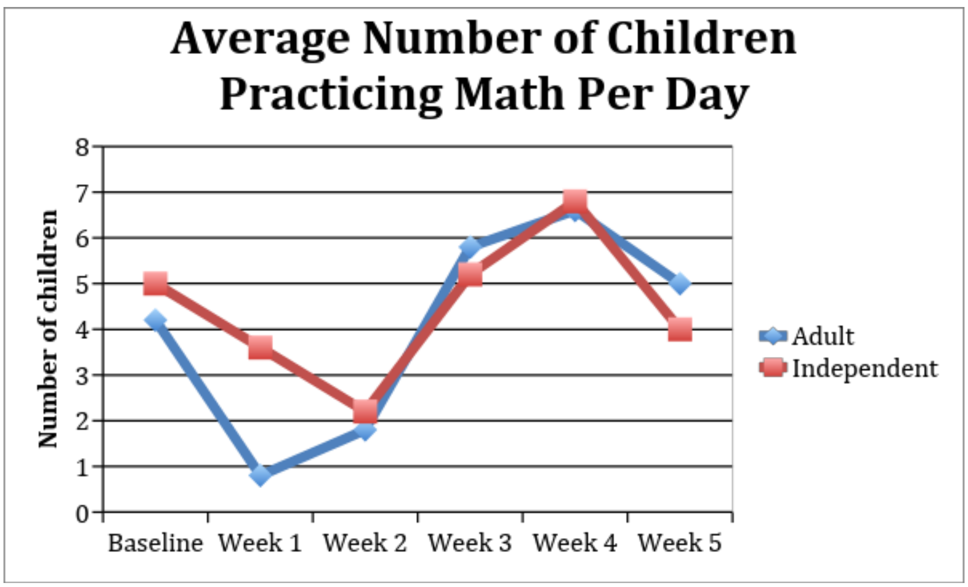

Figure 2: Adult versus Independently Initiated Math

Figure 2 shows the change in children practicing math independently versus being asked by an adult to practice math. Most often children were asked to practice math by an adult if they were invited to a lesson or if they had not independently chosen math in a few days. Over the course of the intervention, adult initiated math and independently initiated math closely mirror each other. This similarity further suggests that math practice was influenced by other activities in the classroom unrelated to the intervention.

In addition to analyzing the impact of the intervention on the class as a whole, I also analyzed each child's individual change in math practice. As with the whole class data, each child's math practice varied from day to day depending on other work the child was involved in, absences or other changes to the daily routine. Five children show a decrease in math practice over the five weeks and sixteen children show an increase. Eleven children did not practice math at all for at least one of the five weeks, either due to disinterest or absence. Although the majority of the group increased their math practice over the course of the intervention, it is still more likely that the increase is due to other factors occurring in the classroom.

Although the number of children practicing math increased over the course of the intervention, their focus level did not.

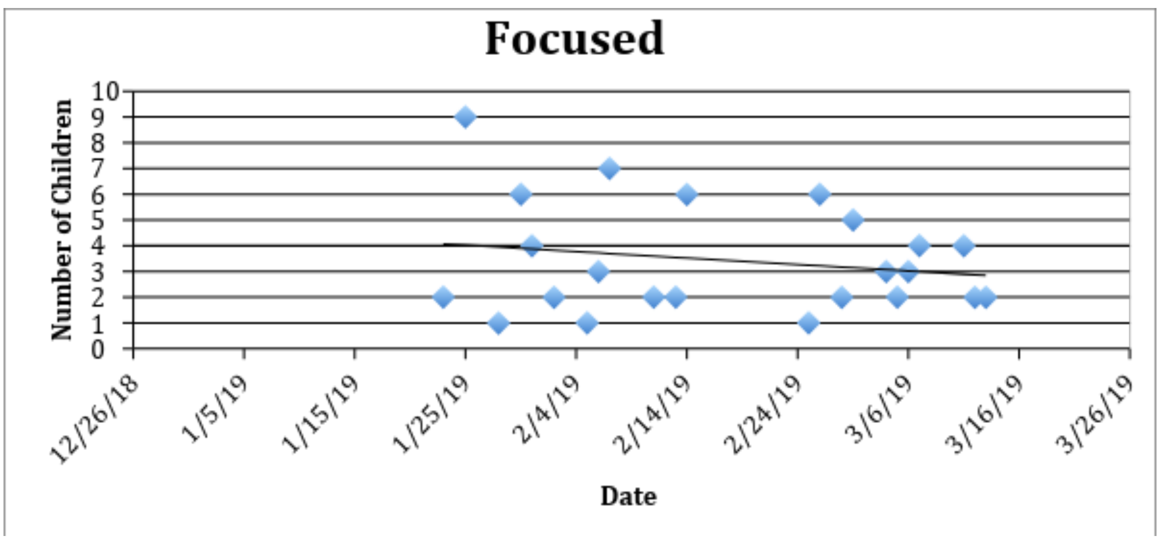

Figure 3: The focus level of the children decreased over the course of the intervention.

Early on in the intervention, I overheard children making comments like "I want to do math all day!" "I'm going to fill up the whole page with problems," or "I want to make sure I can do it without any help." These children demonstrated a high level of focus and concentration, as well as intrinsic motivation. As the intervention continued, I heard more comments like "math lessons are too hard!" or "I only want to do the addition problems, not the multiplication" when addition is easy and comfortable for that child. The data shown in Figure 3 in combination with these comments shows a decrease in the children's motivation toward math. Further, the number of children practicing math, but not focusing on it increased over the course of the intervention.

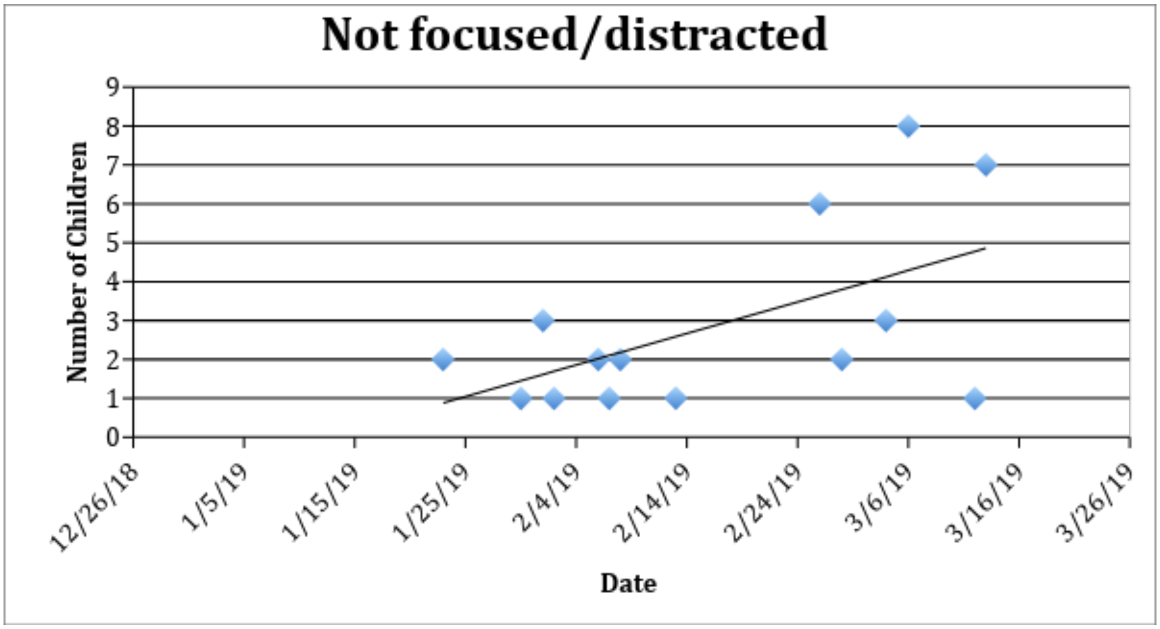

Figure 4: The level of distraction increased over the course of the intervention.

During the last two weeks of the intervention, I increased my reminders to a group of three students to practice math. These three children would save math until the last ten minutes of the day and then choose a type of math that they know well. I observed this type of approach to math practice regularly toward the end of the intervention. As shown in Figure 4, the level of distraction increased even as the number of children practicing math increased. Likely, children chose math that was not challenging enough for them and therefore, they were not engaged. Additionally, they waited until the end of the day to practice math and were not focused on the task at hand.

Before and after the intervention, I asked the children the same set of questions. These questions show the children's mindsets towards math. A "yes" answer to all three questions indicates a growth mindset while a "no" answer to all three questions indicates a fixed mindset.

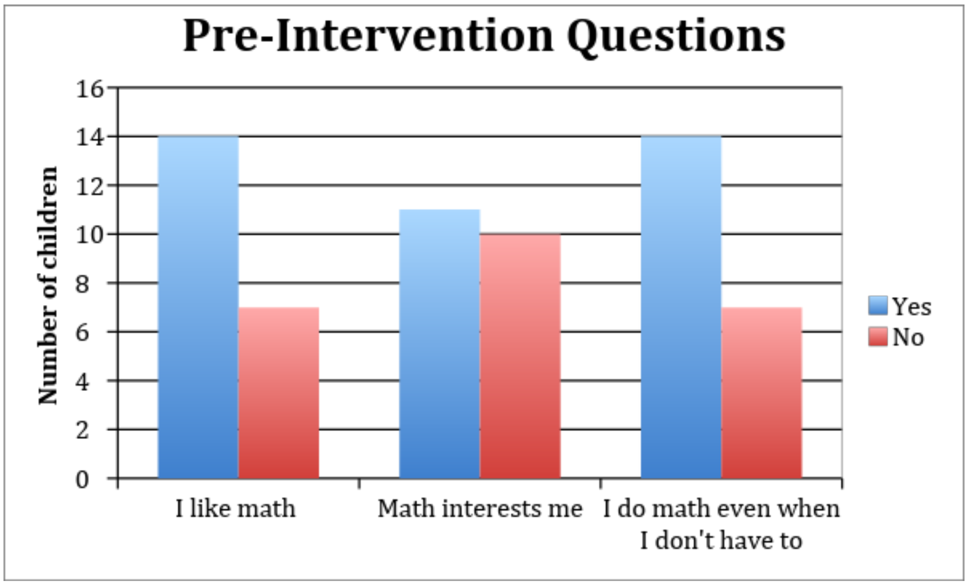

Figure 5: Pre-Intervention Question Responses

In Figure 5, more children have a growth mindset than a fixed mindset toward math. Fourteen children say they like math compared to only 7 who say they do not. However, it is important to note that many children said yes to some questions and no to others. Eight children said yes to all three questions, indicating that they have a growth mindset toward math.

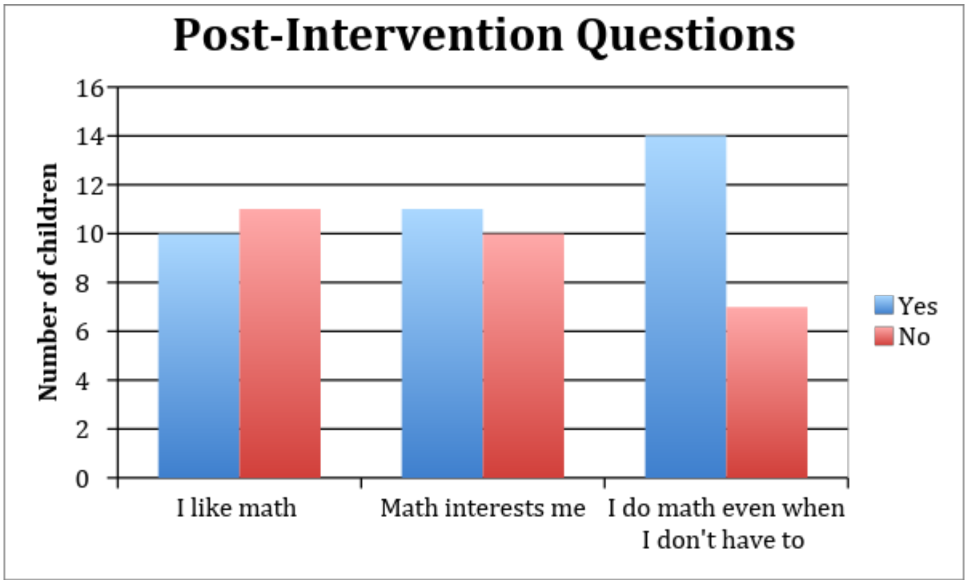

Figure 6: Post-Intervention Questions

For the most part, the responses stayed fairly similar from Figure 5 to Figure 6, suggesting that the children's mindsets were not significantly changed by the intervention. However, the "yes" responses to "I like math" dropped from 14 in Figure 5 to 10 in Figure 6. Frustration with the repetitive nature of the intervention could explain this change. In the fourth week, two children came to me with various complaints about the game "Back to Back," saying that it is "starting to feel repetitive" and we "play this game all the time." These comments, as well as the drop in children who like math, suggests that the intervention had a negative impact on children's intrinsic motivation to practice math.

While the intervention did not encourage children to practice math more frequently, it did increase their interest in math-related games. Starting in the second week of the intervention, children were choosing to play Picot Fermi Bagel independently throughout the work period and during lunch. In smaller groups, the children who did not understand the rules were able to figure out how the game worked and ask questions of their classmates. This in turn increased the number of children raising their hands to participate in the game during the whole group time in the fourth and fifth week of the intervention. While the children could not generalize this interest from the games to math practice in general, the intervention did successfully use their social nature as elementary children to increase their interest in learning the games.

Overall, there was a slight increase in the number of children practicing math per day. However, this change was likely more influenced by other factors in the classroom than by the math games. While the number of children practicing math increased, their concentration decreased, indicating a lack of intrinsic motivation or engagement with the material.

Action Plan

The intervention did not substantially change the children's mindsets towards math, although the number of children who reported liking math decreased, possibly because of the repetitive nature of the games and the structure of the intervention. Over the course of the intervention, the number of children practicing math regularly increased slightly. However, the number of children practicing math in a focused manner decreased. When looking at individual children, most of them showed an increase in the frequency of their math practice. Overall, introducing math games into the classroom had some positive effects, but did not substantially change the motivation of the children towards math.

In the future, I plan to target individual children who display a lack of motivation toward math, especially those who regularly do not practice any math for a week or more. When I meet with each child individually, I plan to point out their inconsistent practice by using their daily work journals. The child's journal often clearly shows patterns in work habits and from that I can jumpstart a conversation about the importance of consistency. Through ongoing conversations, I hope to bring their attention to their sporadic practice habits and help them manage their time effectively.

For a different action research project, I could identify the children in my class who are the least motivated to practice math, perhaps all of the children who answered no to all three pre-intervention questions. Then, I could meet weekly with each of these students and help them reflect back on their math practice over the previous week. Would the frequency of practice increase and would they truly change their habits over time, moving to not needing the weekly check-in anymore?

Especially for those children who are not in the habit of practicing new math concepts consistently, I am curious how many of them have forgotten how to use the materials. In the future, an action research project could investigate what happens when you repeat the same math lesson with the same children, perhaps with an extension for variety. Would this increase their motivation to practice math because they had the opportunity to develop a deeper understanding of the concept? In this project, it could work well to target a few basic math lessons in the elementary classroom. The introductory lesson to factors would work well, because each time you could find the factors of a different number. The checkerboard is another lesson that often needs a few repeat presentations before the children understand how to use the material correctly and independently. In order for this intervention to be successful, the researcher would need to provide variety within the repetition to maintain the interest of the elementary child.

I do expect to continue to see the children playing the math games that I introduced in this intervention throughout the rest of the school year, especially Picot Fermi Bagel. That game seemed to be the most accessible of the three based on how often children wanted to play independently. Buzz and Back to Back needed more guidance and many children never got the hang of how the game worked. Picot Fermi Bagel emphasizes place value and logical thinking, both of which are important foundational mathematical skills. In this way, the intervention positively affected the students' learning.

For children who were already interested in math, the games provided new opportunities to interact with their friends while practicing math skills. However, in the future, it would likely be more effective to narrow my focus to the children who lack intrinsic motivation toward math. I could choose to either have regular discussions about their math practice with each child individually, or repeat certain key math lessons more frequently, or perhaps both. Ultimately, having a strong understanding of fundamental math concepts early in elementary school is important preparation for later success in school and the key to developing that understanding is an interest in the subject matter as well as the motivation to practice new mathematical skills.

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Appendix A

Pre and Post-intervention Discussion Questions

	Yes	No
I like math.		
Math interests me.		
I do math even when no one asks me to		

Appendix B

Observation Sheet

Date: ______________________.

Number of children present: ________Weather: ______________.

General notes:

Nam e	Chose math independently or was asked to do math by an adult	Activity chosen	Amount of Time Spent on Activity	Alone or With a Partner

General observations for the day – Any overheard conversations or comments from the children regarding math and their attitude?