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Cover Page Footnote

We would like to thank Joy Kalfus and Bedtime Math for providing the supplies for our club.

The Impact of After-School Math Club on Elementary Student Math Anxiety

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Many students experience math anxiety, which can harm mathematics achievement. Taking part in fun, hands-on, inquiry-based math activities has been shown to decrease student anxiety. For four semesters, we ran an after-school mathematics club at Presbyterian Day School in Cleveland, MS for students in grades 3-5. The activities and materials were supplied by Crazy 8s Math Club (a Bedtime Math company). In this manuscript, we share three specific activities that encouraged both student engagement and problem-solving skills. Then we discuss survey results from the Crazy 8s Math Club as they relate to lower student math anxiety.

Keywords: Math Anxiety, Elementary Mathematics, Afterschool Math Club

1 Background

In the United States math anxiety is "widespread and often tied to poor math skills" [2]. Math anxiety deprives individuals of their working memory capacity, a crucial cognitive resource necessary for effectively solving mathematical problems. Adult role models, including parents or guardians, can influence the development of young children's mathematical knowledge and experiences within various contexts [3, 6, 11]. Adults and females report higher levels of math anxiety than their peers [8]. In the early years of elementary school, parents' math anxiety, which according to [8], has been tied to the amount of time since the last educational experience, has a detrimental connection with their children's math accomplishments. However, Schaeffer and colleagues [12]

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found that interventions that engage parents and children jointly can yield significant and enduring improvements in children's academic performance. Furthermore, altering parents' outlook on their children's mathematical capabilities and the importance they assign to their success in math contribute to the long-term impact of these interventions [12]. Active involvement of parents during the initial stages of their children's math education has been shown to enhance academic growth and promote higher math achievement [6].

In a climate of high-stakes testing, teachers may avoid using fun hands-on inquiry-based math activities during class. After-school math clubs can provide children with joyful mathematics learning experiences [7, 13, 16]. After-school math clubs afford children supplementary opportunities to enhance conceptual comprehension of mathematics and foster favorable perceptions of themselves as math learners [1]. Stenmark and colleagues' [14] FAMILY MATH engages families by inviting them to schools to participate in entertaining math activities collectively. After-school family math nights facilitate parents' understanding of new math standards, math manipulatives, and the utilization of problem-solving techniques and active learning methods in math education. Additionally, students who participated in an after-school math walk club exhibited a noticeable improvement in their attitudes and interest towards math [15].

1.1 Inspiration for Starting Club

During the summer of 2018, we read the article "How to help children overcome math anxiety" by Sharon Lurye in the Hechinger Report [9]. In this article, the President of Barnard College and cognitive scientist, Dr. Sian Beilock, shares the results of her research as well as a personal story. Dr. Beilock conducted studies with a team of researchers that have found that math-anxious people do not approach basic arithmetic problems as efficiently as people with low math anxiety. They proposed that math-anxious people may be overthinking the problems, or they may have to apply additional effort to avoid their negative thoughts about mathematics. Dr. Beilock has also contributed to a study that found that parents pass math anxiety down to their children. A randomized field experiment of 587 first-graders used the Bedtime Math app at home to promote interactions between children and parents relating to math. The free app (developed by the non-profit Bedtime Math Foundation) has word problems that are designed for parents and children to approach together. Children who engaged in math story time with their parents showed significant increases in math achievement and decreases in math anxiety across the school year. The greatest impact was found for children whose parents them-

selves were anxious about mathematics. This study suggests that high-quality parent-child interactions involving mathematics at home help break the intergenerational cycle of low math achievement [3]. Beilock also shared that she and her daughter regularly use the app and that her daughter enjoys it.

This article motivated us to explore the Bedtime Math website. On the website, we found a link to the Crazy 8s Math Club as well as a John Hopkins University study by Lisa Feigenson that showed that, in only 8 weeks, the club significantly reduced students' math anxiety. We decided to start a club in our town that fall.

1.2 Logistics of Coaching

Starting a Crazy 8s Math Club involves just a few simple steps. Adults first complete an online application. Potential coaches must agree to adhere to a coaching honor code. This code includes the following requirements:

1. Offer Crazy 8s as a recreational math club for kids of *all* math abilities.
2. Register a minimum of 12 and a maximum of 16 kids.
3. Group kids in grades K-2 or 3-5. Yes, you can run the club for only one or two grades, and we do offer the option of grouping grades 1-3 and 4-5. But you cannot expand the grade ranges in any other way.
4. Run the club before school or after the school day has ended.
5. Run the club for one hour weekly over eight consecutive weeks, so kids appreciate math as a regular part of their lives.
6. Host the club during the school year only, not during the summer months.

After we were approved as coaches, Bedtime Math sent us a kit of supplies for season 1. These supplies include the majority of materials needed to run all activities and a colorful follow-up flier for parents printed on cardstock (to send home with students each week). We were also emailed credentials to login to a coaches-only Crazy 8s website. On this website, we found a recruitment letter to send home to parents, recruitment flyers and posters (also available in Spanish), thorough lesson plans (with a script of what to say and directions on what to do), and training videos for each of the season's eight weekly activities. Coaches are not required to be mathematicians or mathematics teachers. The website includes a Math Tips worksheet to assist coaches with a review of the mathematics skills covered each week. Within one week, we had a waitlist

of students interested in joining our club. We decided to hold our meetings from 3-4 PM once a week at an elementary school across the street from the university where we work.

Crazy 8s includes four seasons of unique activities. 16 3rd-5th graders participated in season 1, twelve 4th and 5th graders participated in season 2, and 12 5th and 6th graders participated in season 3. Season 4 was not completed due to COVID-19 teaching restrictions (we began but did not finish). We made a conscious decision after coaching season 1 to limit the number of students to 12 due to the amount of one-on-one assistance for several of the activities. We found 16 students to be too large of a group to effectively facilitate. We have found that 12 students (seated at four round tables with three students per table) was much more manageable. We also decided to exclude 3rd graders during later seasons as these students needed prerequisite skills, such as multiplication and division, for many of the activities. We also found that the cognitive and social development differences between 3rd and 5th graders were too large for the students to effectively collaborate [4].

2 A Sampling of Club Activities

Each season includes eight activities. In this section, we discuss three activities that we found particularly engaging and that promoted discourse, such as problem-solving approaches or relationships to other applications. During season 1 we enjoyed "Bouncy Dice Explosion." For this set of activities, students toss bouncy rubber dice to determine dice sums, play "War" to see who has the high roll, and then move to a giant human Bingo board during which students compete as teams. In the game of "War," students are grouped into pairs and each student rolls a pair of dice; the student with the higher dice sum is the winner of the round. After 10 rounds, the student with the larger number of wins is declared the winner of the game. Students quickly noted that this game of "War" is very similar to the card game with the same name. In the card game of "War," the deck of cards is split between two players, players each turn over one card, and the player with the higher card keeps both cards. The game continues until one player has the entire deck of cards. Students suggested that this card game of "War" could be made more interesting if it were played using two cards, and the higher card sum determined the winner of the round. For the Bingo game, students roll three dice and consider the sum of the dice. Students are allowed to "stand" on any factor of that sum (Figure 1).

Drs. Dean and Bondurant found this particular activity both challenging and rewarding; students definitely found it engaging as students were actively

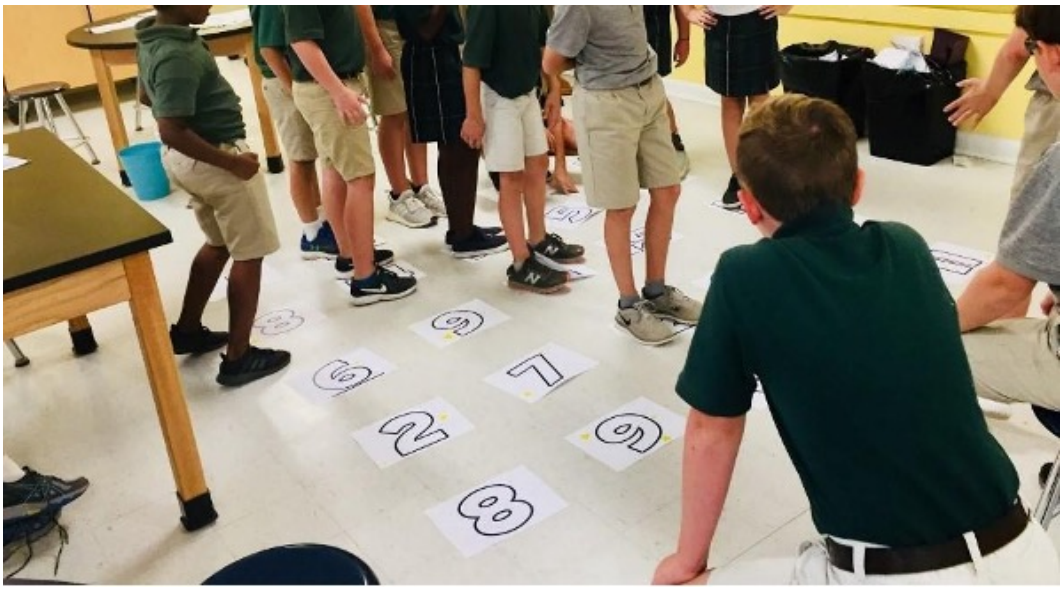

Figure 1. Students work on their arithmetic facts and combinatorial skills in the activity "Rock 'n' Roll Bingo" (Season 1, Week 2).

moving and doing mathematics simultaneously. These "Bouncy Dice Explosion" activities emphasized addition/multiplication skills and utilized combinatorics and probability themes while enhancing strategic thinking skills. For example, in the human bingo game, students quickly discovered that it was fairly easy to obtain the "2" space; all students had to do was roll an even sum since the integer 2 is always a factor of an even sum. On the other hand, the space "7" would be much more difficult to obtain since only sums of 7, 14, 21, and so forth would allow students to stand in that space. Thus, when students rolled a sum such as 14, the students knew to stand on the "7" or "14" instead of the "2", since students knew they were much more likely to obtain the "2" space at a roll as opposed to the "7" or "14."

In season 2 one of our favorite activities was "Glow-in-the-Dark City." In this session, students learned about polyhedrons, pattern recognition (shapes and numbers), ratios, and division by building 3D shapes using glow sticks and styrofoam balls (Figures 2, 3). Students first constructed houses out of cubes. Then, they put all of their houses together to form an apartment building containing many units (Figure 3). They discussed how quickly they were able to assemble the apartment building as the individual units had already been completed. Students then hypothesized how to create additional known objects using faces other than the square. In particular, students discussed using a pentagon for the faces. Students then built 3D models for this and

discovered that they were indeed making a soccer ball (Figure 2, right image).

Figure 2. Students build 3D regular polyhedra out of glow sticks and styrofoam balls in the activity "Glow-in-the-Dark City" (Season 2, Week 1).

Figure 3. Students put 3D regular polyhedra together to form an apartment building containing many units (Season 2, Week 1).

In season 3, we particularly enjoyed "Crayon Craze." In this set of activities, students reinforced addition, subtraction, multiplication, skip counting, estimation, fraction recognition, bar graphing, and perimeter calculation skills

by doing colorful math to count, sort, and size up the hottest crayon color (Figure 4). Students were directed to find the crayon color that occurred the most. At first, students divided the crayons among themselves. They initially planned to count all the reds, greens, and so forth, individually, and then add the results together. The students quickly recognized that this technique was going to take a lot of time. Next, students decided to each take their own group of crayons and sort by color. Once this was completed, they put all groups of colors together as a class, such as all the reds for the class, all the greens for the class, and so forth. Within each group, students then made groups of size 10 to make counting easy within the groups. Students very quickly were able to determine that red was the most common color. This activity led to a good discussion of how multiple approaches may be used to solve a problem, but how, sometimes, one may be more efficient than others.

Figure 4. Students work with a bin of over 250 crayons to to create a bar graph (left) and then determine statistical measures of center and spread (right) in the activity "Crayon Craze" (Season 3, Week 3).

3 Student Outcomes

After each session, students, parents, and teachers provided us with positive feedback about how much students were learning and enjoying participating in the after-school math club. For example, several parents reported their children coming home and excitedly sharing their experiences. Moreover, teachers regularly thanked us and reported students expressing eagerness to attend the club on the days we met. However, after season 1, we decided that we wanted to see if our club was having an impact on students' math anxiety. During the Winter Intersession, we searched for an elementary math anxiety survey and decided to use the Abbreviated Math Anxiety Scale (AMAS) [10]. The AMAS includes nine items (see Appendix). Caviola and colleagues [5] found that items 1, 3, 6, 7, and 9 load onto a "Math Learning Anxiety" factor. Items 2, 4, 5, and 8 were found to load onto a "Math Testing Anxiety" factor.

The directions ask students to imagine themselves in the situations described and to evaluate each situation in terms of how much fear students feel during the specified activities. Since the survey was for young children we decided to modify the Likert scale presentation by using a spectrum of smiley faces instead of a numeric scale. The Likert scale for the AMAS ranges from 1 to 5 (1 = high anxiety, 2 = quite a bit of anxiety, 3 = moderate anxiety, 4 = some anxiety, 5 = low anxiety). Our scale ranged from a pronounced smile to a pronounced frown.

For seasons 2 and 3, we administered the AMAS before engaging in the Week 1 activities and then again at the end of the Week 8 activities. We coded the responses and then analyzed the results. Table 2 shows the median responses by item number for both the Week 1 (pre) and Week 8 (post) results. The Wilcoxon signed rank sum test was then run to determine if Week 8 results were higher than Week 1 results; that is, we looked to determine if student math anxiety was lower after the Crazy 8s Math Club. Standard normal scores along with their corresponding p-values are also given in Table 1. As all p-values are below 5%, we conclude that both learning anxiety and math testing anxiety were reduced at the end of the club.

Table 2.

AMAS Results.

Item	Pre-Median	Post-Median	Z	p
1. Having to use the diagrams and multiplication tables in the back of a math textbook.	4	5	2.98	0.0015
2. Thinking about the upcoming written math test you have tomorrow.	4	4	1.98	0.0239
3. Watching the teacher break down a complex problem on the blackboard.	3	5	2.64	0.0041
4. Doing a written math examination/ test.	3	4	2.98	0.0014
5. Having to solve many difficult math problems for homework due the next class lesson.	3	4	3.27	0.0005
6. Carefully listening to the math lesson.	3	5	2.96	0.0016
7. Watching another student solve a math problem.	4	5	1.98	0.0239
8. Having an oral test on math without knowing in advance.	2	3	3.09	0.001
9. Starting a new topic in mathematics.	4	5	2.49	0.0064

We acknowledge the weaknesses of our investigation into changes in student anxiety. For one, the students took the survey at a round table with their peers seated nearby. Despite asking students to keep their eyes on their papers and not discuss their responses while completing the survey, we noticed students looking at the responses of their peers and discussing their responses. Therefore, we think that some students may have been influenced by their peers' responses. We also told students that their responses would not be shared with their math teacher or impact their grades in math class. We wonder if some students randomly completed their surveys without thoughtfully reflecting on their responses. Finally, despite using the smiley

face scale to simplify the survey, we wonder if some students were confused about the scale and may have interpreted the scale incorrectly. For future administrations, we suggest addressing each of these potential issues.

4 Conclusion

In conclusion, our manuscript highlights the positive impact of an after-school math club on elementary students' math anxiety. By engaging students in fun, hands-on activities provided by the Crazy 8s Math Club, we observed a noticeable decrease in math anxiety levels among participants. Through activities like "Bouncy Dice Explosion," "Glow-in-the-Dark City," and "Crayon Craze," students not only enhanced their mathematical skills but also developed a more positive attitude towards math. The findings from our survey using the Abbreviated Math Anxiety Scale (AMAS) indicate a significant reduction in both math learning anxiety and math testing anxiety after participating in the club. While our investigation acknowledges certain limitations, such as potential peer influence and scale interpretation, the overall outcomes suggest that after-school math clubs can serve as effective interventions to alleviate math anxiety among elementary students. Moving forward, addressing these limitations, and further exploring the long-term effects of such clubs could provide valuable insights into promoting positive math experiences for young learners.

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Appendix: Abbreviated Math Anxiety Scale (AMAS)

Item	High Anxiety	Quite a Bit of Anxiety	Moderate Anxiety	Some Anxiety	Low Anxiety
1. Having to use the diagrams and multiplication tables in the back of a math textbook.					
2. Thinking about the upcoming written math test you have tomorrow.					
3. Watching the teacher break down a complex problem on the blackboard.					
4. Doing a written math examination/ test.					
5. Having to solve many difficult math problems for homework due the next class lesson.					
6. Carefully listening to the math lesson.					
7. Watching another student solve a math problem.					
8. Having an oral test on math without knowing in advance.					
9. Starting a new topic in mathematics.					