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Student-Guided Math Practice in Elementary School: Relation among Math Anxiety, Emotional Self-Efficacy, and Children's Choices When Practicing Math

Aditi Tarkar *, Brandie Matalka, Macey Cartwright and Heidi Kloos *

Department of Psychology, University of Cincinnati, Cincinnati, OH 45221, USA
* Correspondence: tarkarai@mail.uc.edu (A.T.); heidi.kloos@uc.edu (H.K.)

Abstract: In the current study, we explored math anxiety in the context of a special kind of math practice, one that allowed for some flexibility on the part of the students. Such student-guided math practice is conducive to exploring how math anxiety relates to children's day-to-day experiences with math, potentially yielding insights into math anxiety that would not be available otherwise. Students in Grades 3 and 4 (N = 26) could choose math problems that were below, at, or above their proficiency level. They also completed a math-anxiety survey and an emotional self-efficacy survey. Descriptive results revealed that math anxiety was implicated in two negative outcomes of math practice: children's tendency to avoid challenging math problems and children's relatively low success rate when working on class-level math. Finding that math anxiety relates to several negative experiences could explain why math anxiety can persist. Importantly, results show that emotional self-efficacy plays a role in both children's willingness to challenge themselves and their success rate. This adds to the ongoing discussion on whether emotional self-efficacy can compensate for the negative effects of math anxiety.

Keywords: self-regulated learning; emotional maturity; autonomy; field study

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1. Introduction

Math anxiety is a well-known handicap to education [1,2]. There are also insights about the mechanisms by which math anxiety affects learning [3]. However, there is much less work on how math anxiety develops and changes. In the current study, we seek to contribute to this conversation by looking at children's behavior during student-guided math practice. Such practice provides a novel window into how children approach learning and, thus, into how math anxiety might take shape. To begin, we briefly review the literature on math anxiety, after which we turn to the idea of student-guided math practice.

1.1. Math Anxiety

There is extensive work on the detrimental effects of math anxiety on math learning [4–10]. For example, high-school students with high math anxiety are more likely to avoid selecting elective coursework that involves math, and less likely to select a STEM major, compared to students with low math anxiety [11]. The effects of high math anxiety even persist past school: Individuals with high math anxiety tend to avoid opportunities involving math in their adult lives [12–15].

There is also extensive work on measuring math anxiety, in both children and adults. Math anxiety scales for children include the Mathematics Anxiety Rating Scale-Elementary (MARS-E) [16], the Scale for Early Math Anxiety (SEMA) [8], the Mathematics Anxiety Scale for Young Children (MAYSC) [17] the Children's Anxiety in Math Scale (CAMS) [18], and the Child Math Anxiety Questionnaire (CMAQ) [3]. There are also several revised versions, including the Child Math Anxiety Questionnaire-Revised (CMAQ-R) [19] and the revised version of the Math Anxiety Scale for Young Children (MASYC-R) [20].

Adding to the empirical work, there are several proposals on the mechanisms by which math anxiety might operate. For example, math anxiety is linked to an abnormal increase in brain activity in structures responsible for fear and negative emotions (right amygdala), and it is linked to reduced brain activity in structures responsible for numerical processing (posterior parietal lobe) [21]. Math anxiety is also linked to reduced activity in structures responsible for executive function (dorsolateral prefrontal cortex; intraparietal sulcus) [22,23]. In terms of learning, math anxiety might create a kind of stress that leads to lower working memory capacity and forgetting [24,25].

Yet, despite extensive empirical and theoretical work, questions remain. Most prominent is perhaps the question on how to best combat math anxiety. Research suggests that math anxiety is easily transferred from parent to child, for example when parents work with their children on math [26]. However, it is far more difficult to remove a child's math anxiety once established. For example, while there are several interventions designed to address math anxiety [27–31], a systematic review found only few true successes [32]. In the current paper, we contribute to this conversation looking at math anxiety in the context of children's math practice.

1.2. Math Practice

Math practice is an essential aspect of math learning. This is because the mind has not evolved to learn math, which means that an understanding of math cannot be trans-mitted directly, merely by illustrating relevant concepts, operations, or principles [33]. Instead, students need to practice math on their own in order to understand necessary concepts and adapt their attention to be able to use them flexibly. It is perhaps for this reason that math practice is a stable aspect of math learning, whether during school hours (e.g., by using worksheets) or outside of school (e.g., by assigning homework).

Yet math practice is not without hurdles. For example, in order to engage in math practice, numerous decisions have to be made that can be taxing on students (e.g., on how to approach a given math problem, whether to make a guess, whether to give up, etc.). Math practice can also be frustrating, as learners might be asked to practice something that they are not fully familiar with. Students have to be willing to persist in the face of challenges and setbacks (e.g., when the answer to a math problem is not obvious, or when a math problem is solved incorrectly).

Given the hurdles of math practice, various socio-emotional factors are likely to affect it. Indeed, previous research has shown that math practice is often delayed or put off altogether [34]. In fact, math anxiety was found to exacerbate procrastination, which, in turn, was found to fuel an increase in math anxiety [35,36]. These findings highlight the role of math anxiety in children's day-to-day decision-making. Importantly, they illustrate some principles by which math anxiety might take hold. Thus, the study of math practice can provide a novel window into understanding the development and change of math anxiety.

1.3. Emotional Self-Efficacy

As a way of exploring possible solutions to math anxiety, we explored emotional self-efficacy in the context of math practice. The general concept of self-efficacy refers to a person's beliefs in his or her own competences, known to play an important role in well-being [37]. Without confidence in one's own abilities, there would be no incentive to push through barriers and persist in achieving a desired outcome. If an individual were to question whether their own actions will affect an outcome, even a small challenge is likely to become a deterrent [38–40]. Thus, self-efficacy affects the perception of roadblocks, which is tied to an individual's persistence and resilience [41].

One such perceived competence is known as emotional self-efficacy [42–44]. It refers to the ability to identify and manage one's own emotions, as well as to perceive and deal with the emotions of others [45–47]. Emotional self-efficacy is indeed predictive of a vast range of behaviors. For example, it is related to measures of intelligence, academic success, social behaviors, and career success (for a review, see [48]). Emotional self-efficacy is also likely to matter during math learning. This is because math learning can yield negative experience for children and, thus, requiring children to control their negative feelings.

Several scales are currently available to measure emotional self-efficacy in youth, including the Self-Efficacy Questionnaire for Children (SEQ-C) [47], the Emotional Self-Efficacy Scale for Young Adolescents (Youth-ESES) [46], and the Regulatory Emotional Self-Efficacy scale (RESE) [49,50]. Findings with adolescents show a negative correlation between self-efficacy levels and mental health (e.g., depression, anxiety) and conduct problems [51,52]. These findings complement the theoretical model of the relevance of self-efficacy offered by Bandura [53,54].

Relevant to our study is the relation between self-efficacy and math anxiety, concepts that have been found to constitute separate aspects of behavior (cf., [55,56]). Previous research shows that math self-efficacy affects the relation between math anxiety and math performance in undergraduate students [57]. More specific to emotional self-efficacy, research found that it affects the relation between attentional control and behavioral problems in preadolescent youth [58]. There is also evidence that emotional self-efficacy moderates the relations between anxiety and children's performance on standardized math tests [59]. Building on these results, we sought to explore the extent to which emotional self-efficacy matters in the relation between math anxiety and students' decision-making during math practice.

1.4. Overview of the Current Study

In order to explore the relations between math anxiety, emotional self-efficacy, and student-guided math practice, we obtained data on a math-practice program in which students were given a choice over what to practice. Specifically, elementary-school students could choose whether to practice math that was below, at, or above their own proficiency level. Students were also asked to complete a standardized math-proficiency assessment, a math-anxiety survey, and an emotional self-efficacy survey. Our question was whether math anxiety and emotional self-efficacy played a role in students' math-practice behavior.

2. Method

The method follows a field-study design (cf., [60]). Specifically, we were provided with the de-identified data on activities students had completed as part of their regular schoolwork to meet the educational mission for the school. Therefore, students do not act as participants in this design. Instead, research is based on the data set made available by the school, approved by the Institutional Review Board to ensure ethical treatment of participants. Below, we describe the nature of the data obtained.

Data Set

The semester-long math-practice program that produced the data was carried out at a small urban school that serves families from socio-economically disadvantaged neighborhoods. A full set of measures was available from 26 students from Grade 3 (N = 14; 7 boys) and Grade 4 (N = 12; 6 boys). Data from an additional group of seven students (N = 3 third-graders; N = 4 fourth-graders) were made available but was not complete. Data from these students were consequently excluded from the analyses.

The central feature of the math-practice program was that students had a choice about what to practice, using the online math-practice app IXL [61]. IXL logs every math problem a student attempted, as well as the amount of time it took the student to solve it, the student's answer, and whether the student's answer was correct. The data set obtained contained information about the amount of time students practiced math problems of a certain difficulty level, the number of math problems completed, as well as whether the problems were solved correctly or not.

As part of continuous improvement of the math-practice program, students completed various surveys. One of these surveys pertained to math anxiety. The Mathematical Anxiety Rating Scale-Elementary was used for this purpose (MARS-E) [16]. It contained 26 items related to various encounters of math (e.g., adding up a cash register receipt after having bought several things). Students were asked to rate each statement on a 5-point Likert scale, from "not at all nervous" to "very, very nervous". For example, students were asked to "Mark how nervous or tense you would feel if you had to decide if this problem is right: (3 + 4) + 2 = 4 + (2 + 3)". The minimum score on the assessment is 26, and the maximum score is 130.

Another survey pertained to emotional self-efficacy. A rapid-assessment measure was used to capture students' confidence in regulating their own negative emotions (see also [62]). Two existing subscales formed the basis for this measure: a subscale of the SEQ-C (normed for children 14 and older) [47] and a subscale of the Youth-ESES (normed for children 11 and older) [46]. The resulting self-efficacy scale contained eight items relevant to emotional control (e.g., "I know how to stop being angry if I want to"; see Appendix A for the full list). Items were read to students by an adult one-on-one. Students were asked to rate each item on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Averaging across responses, the minimum score is 1, and the maximum score is 5.

Finally, students also completed various math assessments. The assessments available for this research pertained to two subscales of the Woodcock-Johnson test battery. One of the subtests was designed to assess students' math fluency: It is a three-minute timed test that presents students with simple arithmetic items (addition, subtraction, multiplication). The second subtest was designed to assess students' calculation competence: It is an untimed test that presents students with increasingly more difficult math problems. In both cases, the number of correctly solved problems was standardized to yield a grade-equivalent score (i.e., a score that reflects the grade level of the displayed proficiency). The average of the two scores was taken to reflect math proficiency, again expressed as a grade-equivalent score.

3. Results

Given the nature of the data set (e.g., the small number of students participating in an idiosyncratic enrichment program), data are presented as trends, without inferential analyses. We first describe the data separately for each measure (math anxiety, emotional self-efficacy, math proficiency, math-practice behavior). Of interest here is the distribution of variables as a function of students' gender and grade level. We then describe the degree to which math anxiety and emotional self-efficacy are related to the math outcomes (math proficiency, math-practice behavior).

3.1. Relevance of Gender and Grade Level

Table 1 provides information about students' math anxiety and emotional self-efficacy. Specific to math anxiety, we found that boys had generally lower scores (M = 64.62; SD = 17.30) than girls (M = 78.15; SD = 19.31). There was no difference by grade level. Emotional self-efficacy, on the other hand, was neither related to gender (M_{Boys} = 3.30; M_{Girls} = 3.62) nor to grade level. We also found that math anxiety was unrelated to emotional self-efficacy ($r < 0.06$), suggesting that the two measures tap into separate aspects of behavior. For this reason, we created four categories of students, depending on whether students' scores fell below or above the respective means of math anxiety and emotional self-efficacy.

Table 2 provides information about students' math proficiency. Findings show that many students scored below their actual grade level, both in math fluency (42.86% of third-graders; 41.67% of fourth-graders) as well as in calculation competence (71.43% of third-graders; 91.67% of fourth-graders). At the same time, there were some students who scored above their grade level for math fluency (N = 3 third-graders; N = 4 fourth-graders). Findings also show that boys scored generally higher than girls in math fluency, but not in calculation competence. On average, students scored one grade level below their actual grade.

Finally, Table 3 provides information about the difficulty level of the chosen math problems. Findings show that girls spend more time practicing math than boys, independently of the difficulty level. This difference is particularly striking for problem sets that were above students' math proficiency. That is to say, girls tended to challenge themselves more than boys. There was also a difference in practice patterns between third- and fourth-graders:

Third-graders spent more time practicing than fourth-graders, independently of difficulty level. And third-graders challenged themselves more often than fourth-graders (whether when this was measured in number of minutes or number of math problems attempted).

Table 1. Descriptive statistics of math anxiety and emotional self-efficacy.

	Math Anxiety (MA)		ESE across MA Categories	ESE across All Categories
	Low	High		
Emotional Self-Efficacy (ESE)				
High	$N = 6$ $M_{MA} = 55.17$ $M_{ESE} = 4.27$	$N = 6$ $M_{MA} = 92.00$ $M_{ESE} = 4.02$	$N_{Boys} = 5$ $N_{Girls} = 7$ $M = 4.15$	$M = 3.46$ ($SD = 0.75$) Median = 3.38 $min = 2.12$ $max = 4.50$ $M_{3rd} = 74.86$ $M_{4th} = 67.33$
Low	$N = 9$ $M_{MA} = 61.11$ $M_{ESE} = 2.88$	$N = 5$ $M_{MA} = 84.60$ $M_{ESE} = 2.85$	$N_{Boys} = 8$ $N_{Girls} = 6$ $M = 2.87$	
MA across ESE categories				
	$N_{Boys} = 10$ $N_{Girls} = 5$ $M = 58.73$	$N_{Boys} = 3$ $N_{Girls} = 8$ $M = 88.64$		
MA across all categories				
	$M = 71.38$ ($SD = 19.24$) Median = 68.00 $min = 29.00$ $max = 119.00$ $M_{3rd} = 3.43$ $M_{4th} = 3.49$			

Note. Categories (high ESE/low MA; high ESE/high MA; low ESE/low MA; low ESE/high MA) were determined based on the respective means.

Table 2. Descriptive Statistics of Students' Math Proficiency.

	Math Fluency		Calculation Competence		Proficiency Level	
	Boys	Girls	Boys	Girls	Boys	Girls
M (SD)	3.9 (1.4)	2.7 (1.6)	2.3 (0.6)	2.3 (0.6)	3.1 (0.9)	2.5 (1.0)
Minimum	1.2	0.7	0.9	1.6	1.1	1.2
Maximum	5.9	5.3	3.1	4.1	4.5	4.0
3rd-Graders	3.5	1.8	2.3	2.0	2.9	1.9
4th-Graders	4.3	3.8	2.3	2.7	3.3	3.2

Note. Each measure is reflected as a grade-equivalent score (i.e., the grade level at which the student is proficient). The math proficiency level was calculated as the average of students' scores on the math-fluency test and the calculation-competence test.

Table 3. Descriptive Statistics of Students' Math-Practice Behavior.

	Difficulty Level of Chosen Math Problems			
	At Class Level	Below Proficiency	At Proficiency	Above Proficiency
Number of minutes practiced				
Total	$M = 324$ ($SD = 165$)	$M = 357$ ($SD = 303$)	$M = 215$ ($SD = 196$)	$M = 135$ ($SD = 162$)
By Gender	$M_{Boys} = 298$ $M_{Girls} = 350$	$M_{Boys} = 336$ $M_{Girls} = 378$	$M_{Boys} = 201$ $M_{Girls} = 229$	$M_{Boys} = 61$ $M_{Girls} = 208$
By Grade	$M_{3rd} = 424$ $M_{4th} = 207$	$M_{3rd} = 359$ $M_{4th} = 356$	$M_{3rd} = 225$ $M_{4th} = 204$	$M_{3rd} = 176$ $M_{4th} = 87$
Number of questions attempted				
Total	$M = 939$ ($SD = 461$)	$M = 1145$ ($SD = 913$)	$M = 599$ ($SD = 586$)	$M = 269$ ($SD = 314$)
By Gender	$M_{Boys} = 865$ $M_{Girls} = 1013$	$M_{Boys} = 1134$ $M_{Girls} = 1155$	$M_{Boys} = 606$ $M_{Girls} = 591$	$M_{Boys} = 159$ $M_{Girls} = 379$
By Grade	$M_{3rd} = 1106$ $M_{4th} = 746$	$M_{3rd} = 1059$ $M_{4th} = 1246$	$M_{3rd} = 574$ $M_{4th} = 628$	$M_{3rd} = 357$ $M_{4th} = 167$

Table 3. *Cont.*

	Difficulty Level of Chosen Math Problems			
	At Class Level	**Below Proficiency**	**At Proficiency**	**Above Proficiency**
Number of math problems solved per minute				
Total	M = 4.31 (SD = 6.17)	M = 3.21 (SD = 1.72)	M = 2.38 (SD = 1.24)	M = 1.58 (SD = 1.66)
By Gender	M_{Boys} = 3.47 M_{Girls} = 5.16	M_{Boys} = 3.71 M_{Girls} = 2.71	M_{Boys} = 2.33 M_{Girls} = 2.42	M_{Boys} = 1.77 M_{Girls} = 1.39
By Grade	M_{3rd} = 2.62 M_{4th} = 6.30	M_{3rd} = 2.47 M_{4th} = 4.07	M_{3rd} = 2.45 M_{4th} = 2.29	M_{3rd} = 1.41 M_{4th} = 1.78
Proportion of correctly solved problems				
Total	M = 87.28 (SD = 14.54)	(Data not available)		
By Gender	M_{Boys} = 83.24 M_{Girls} = 91.33			
By Grade	M_{3rd} = 89.79 M_{4th} = 84.36			

Note. The difficulty level of the math problems was defined either on the basis of the whole class (i.e., class level) or on the basis of individual students' proficiency (i.e., below, at, or above proficiency level).

3.2. *Relevance of Math Anxiety and Emotional Self-Efficacy*

To what extent does math anxiety and emotional self-efficacy relate to students' math performance? We sought to explore this question with three different outcome measures: students' math proficiency, students' willingness to challenge themselves during math practice, and students' success rate when practicing math at the difficulty level that matched the class average (one grade level below the students' actual grade).

Figure 1 shows the data on students' math proficiency assessed at the onset of the practice program, separated by math anxiety and emotional self-efficacy. Results show that students with low math anxiety scored better on math proficiency than students with high math anxiety. This finding is in line with previous findings on the role of math anxiety in math proficiency. More importantly, results show that high-anxiety students with high emotional self-efficacy scored better on math proficiency than high-anxiety students with low emotional self-efficacy. This pattern was not observed in low-anxiety students.

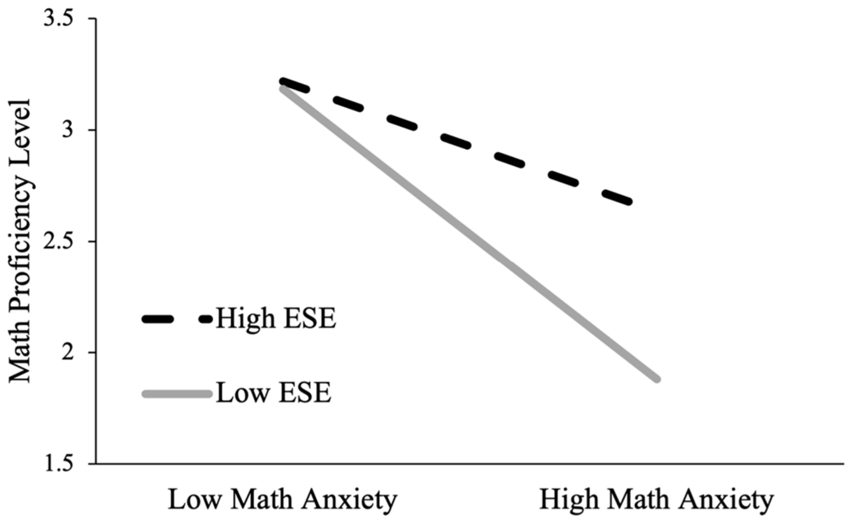

Figure 1. Average math proficiency (expressed as grade level), as a function of students' math anxiety (low vs. high) and emotional self-efficacy (high vs. low).

Next, we considered whether students chose math problems that were at a difficulty level above their own math proficiency. Figure 2 shows the proportion of minutes students worked on such above-proficiency problems. Results show that math anxiety per se was unrelated to the proportion of minutes devoted to above-proficiency problems (i.e., students spent about 20% of time on these problems, independently of math anxiety). However, high-anxiety students who had high emotional self-efficacy chose more often above-proficiency problems than high-anxiety students who had low emotional self-efficacy. A similar pattern was found when we considered the proportion of math problems attempted.

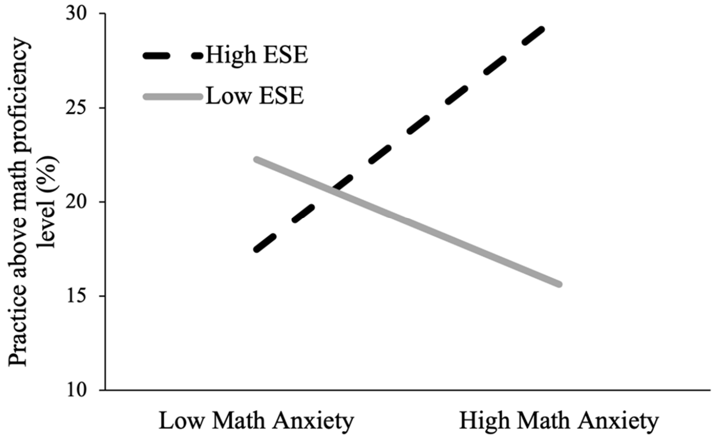

Figure 2. Proportion of minutes spent on math problems that are above the student's math proficiency (expressed as grade level), separated by math anxiety (low vs. high) and emotional self-efficacy (high vs. low).

Finally, we examined the degree to which students could solve math problems successfully at the difficulty level of their class (i.e., one grade level below their actual grade). Figure 3 shows the average proportion of correctly solved problems at this level. As was found with math proficiency, results showed again that low-anxiety students had better success on math problems than high-anxiety students. More importantly, emotional self-efficacy was related to practice success for high-anxiety students: Those with high emotional self-efficacy solved more math problems correctly than those with low emotional self-efficacy. In fact, high-anxiety students with high emotional self-efficacy performed at the level of low-anxiety students. This pattern of results was supported by fourth-graders more so than by third-graders.

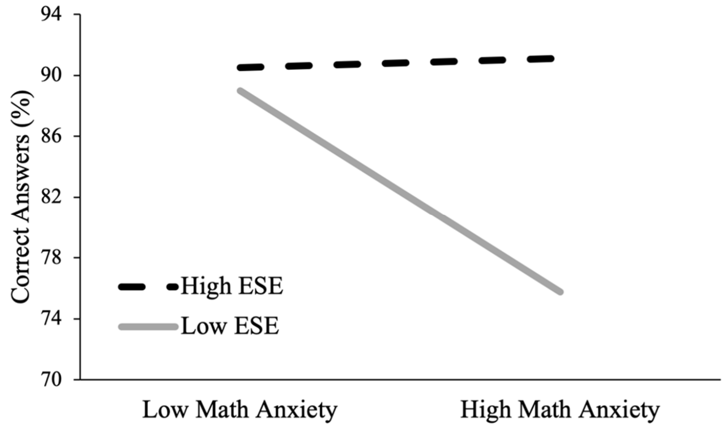

Figure 3. Average proportion of correctly answered questions at the class level (second-grade level for third-graders; third-grade level for fourth-graders). Data are separated by math anxiety (low vs. high) and emotional self-efficacy (high vs. low).

4. Discussion

In the current study, we explored students' math anxiety and emotional self-efficacy in the context of their choices made during math practice. Crucially, students had a choice of whether to challenge themselves during practice. Available outcome variables pertained to the number of minutes practiced, the number of questions attempted, and the proportion of correctly solved problems. In each case, we obtained descriptive results for four groups of children, depending on whether their math-anxiety and emotional self-efficacy scores fell below or above the group average. In what follows, we discuss the results for each outcome variable separately.

4.1. Math Anxiety and Proficiency Level

Extensive prior research has shown that math anxiety plays a role in children's math proficiency. Our results confirmed these claims in a group of third- and fourth-grade students: We found that high math anxiety was related to lower proficiency level. The inclusion of emotional self-efficacy adds to the already existing literature: We found that children who scored high on both math anxiety and emotional self-efficacy had a proficiency level comparable to children who scored low on math anxiety. Thus, the difference in math proficiency between the low-anxiety and high-anxiety group was less pronounced for children who perceived themselves to be capable of controlling their negative emotions.

Prior research is divided on the issue of whether emotional regulation can modulate the relation between math anxiety and math proficiency. Specifically, although Galla and Wood [59] found confirming evidence for this relation (i.e., for elementary-school children, measuring general anxiety), Palestro and Jameson [57] did not (i.e., for college students, measuring math anxiety specifically). Our findings expand on Galla and Wood's findings that emotional regulation is relevant in anxiety-prone behavior. It remains to be seen whether this finding is specific to relatively young children (elementary school) or could apply to adults.

4.2. Math Anxiety and Practice Behavior

The main contribution of our study was to explore children's willingness to challenge themselves during math practice. Indeed, we found some variability in this behavior: Children with high math anxiety showed relatively low willingness to challenge themselves, compared to children with low math anxiety. Furthermore, we found that children who scored high on math anxiety had a relatively low success rate on class-level math problems (i.e., about 80% success rate, compared to 90% for children who scored low on math anxiety). Thus, children with high math anxiety are likely to lose out in two ways when it comes to math practice: They are unlikely to expose themselves to challenging problems; and they are likely to experience a relatively high degree of failure.

Regarding the question of why math anxiety persists, the finding is relevant that math experience can be both limited and frustrating for children with high math anxiety. Previous work has offered speculations of the mechanisms by which math anxiety stabilizes over time. For example, Namkung and Lin [63] describe a bidirectional model by which math anxiety and math performance influence each other in amplifying ways. A mechanism of cyclical relation between math anxiety and math performance was also found in the area of procrastination [35,36]. Our findings offer further details about how such a reciprocal relationship is fueled: Math anxiety locks children out of positive experiences with appropriately challenging problems.

Importantly, the pattern of experiences detected for children who scored high on math anxiety did not hold up when children also scored high on emotional self-efficacy. Children in this latter group completed many problems at the challenging level. Moreover, they experienced success rates comparable to that of children who scored low on math anxiety. The beneficial association of emotional self-efficacy on practice success cannot be explained by differences in math proficiency. It is instead expanding the list of positive effects of emotional self-efficacy, beyond its effect on general math proficiency. This finding further supports the claims of Galla and Wood [59] that highly math-anxious children could benefit from emotional self-efficacy.

In sum, we were able to expand the list of outcome variables that are potentially affected by math anxiety. Specifically, we found that math anxiety was negatively related to children's willingness to expose themselves to challenging math problems, as well as to their experience of success during math practice. We also found that emotional self-efficacy can be relevant. Even though the data set did not identify causal relations, these findings provided insights into how math anxiety could solidify over the years, as well as how it could be curtailed.

4.3. Limitations of the Study

Though promising, the nature of the data set available for our research limited the interpretation of our results. Specifically, our data set was based on a convenience sample of a small group of students, nested within two classrooms. It is possible, for example, that students' behaviors, whether during the math assessments or the math practice, cannot be generalized beyond their classroom culture. Without access to a randomized sample of independent data points, the assumptions for hypothesis testing cannot be met. Thus, the results were merely exploratory, limited to descriptive data points, rather than inferential claims. It remains to be seen if the pattern of findings could be generalized to the larger population of students.

It should also be noted that the math-learning program used in this study featured various idiosyncratic aspects that might have affected students' behavior. For example, the program involved the use of online technology that might have been uniquely motivating to students. There were also adult volunteers present in the classrooms who might have encouraged students to challenge themselves. These features of the math-practice program might have reduced the math stressors that are typically perceived by students with math anxiety [64]. Thus, the claim we make about student-guided math practice is limited to the program employed. It remains to be seen if the same patterns of findings could be generalized to student-guided learning more broadly.

5. Conclusions

Our starting point was the relative gap in our understanding of how math anxiety might develop and change. In order to contribute to this conversation, we explored math anxiety during student-guided math practice. The crucial feature of this kind of practice was that students had the option to decide whether they would like to challenge themselves or not. An exploration of such decision-making offered a novel vantage point by which to understand the role of math anxiety during learning.

Several results are of importance, albeit descriptive in nature. For example, we found that children with high math anxiety were hesitant to choose challenging math problems. Children with high math anxiety were also experiencing relatively low levels of success when practicing math at class level. Both of these results shed light on the mechanism by which math anxiety might get solidified over time, namely by affecting both children's math avoidance and their perception of failure. Importantly, these trends did not hold up for the group of math-anxiety children who scored high on emotional self-efficacy. Thus, there is promise in supporting children's emotional-regulation skills to combat math anxiety.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The full data set can be requested from the corresponding authors.

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Appendix A

Items from the Emotional Self-Efficacy Scale:

1. I'm good at making myself happy after something bad happens.
2. I know how to calm myself down when I get scared.
3. I know how to stop thinking bad thoughts.
4. I know how to talk myself out of feeling bad.
5. I know how to tell a friend when I don't feel well.
6. I know how to make myself feel better when I start worrying about something.
7. I know how to stop being angry if I want to.
8. I am able to stop myself from getting nervous.

Note. The reading ease of these items is 90/100, and the reading grade level is 3.4.

References

1. Luttenberger, S.; Wimmer, S.; Paechter, M. Spotlight on math anxiety. *Psychol. Res. Behav. Manag.* **2018**, *11*, 311–322. [CrossRef]
2. Suárez-Pellicioni, M.; Núñez-Peña, M.I.; Colome, A. Math anxiety: A review of its cognitive consequences, psychophysiologi-cal correlates, and brain bases. *Cogn. Affect. Behav. Neurosci.* **2016**, *16*, 3–22. [CrossRef]
3. Ramirez, G.; Gunderson, E.A.; Levine, S.C.; Beilock, S.L. Math Anxiety, Working Memory, and Math Achievement in Early Elementary School. *J. Cogn. Dev.* **2013**, *14*, 187–202. [CrossRef]
4. Ashcraft, M.H.; Moore, A.M. Mathematics anxiety and the affective drop in performance. *J. Psychoeduc. Assess.* **2009**, *27*, 197–205. [CrossRef]
5. Cates, G.L.; Rhymer, K.N. Examining the Relationship Between Mathematics Anxiety and Mathematics Performance: An Instructional Hierarchy Perspective. *J. Behav. Educ.* **2003**, *12*, 23–34. [CrossRef]
6. Legg, A.M.; Locker, L. Math performance and its relationship to math anxiety and metacognition. *N. Am. J. Psychol.* **2009**, *11*, 471–486.
7. Tsui, J.M.; Mazzocco, M.M.M. Effects of math anxiety and perfectionism on timed versus untimed math testing in mathematically gifted sixth graders. *Roeper Rev.* **2006**, *29*, 132–139. [CrossRef]
8. Wu, S.S.; Barth, M.; Amin, H.; Malcarne, V.; Menon, V. Math Anxiety in Second and Third Graders and Its Relation to Mathematics Achievement. *Front. Psychol.* **2012**, *3*, 162. [CrossRef]
9. Krinzinger, H.; Kaufmann, L.; Willmes, K. Math Anxiety and Math Ability in Early Primary School Years. *J. Psychoeduc. Assess.* **2009**, *27*, 206–225. [CrossRef]
10. Karimi, A.; Venkatesan, S. Mathematics Anxiety, Mathematics Performance and Academic Hardiness in High School Students. *Int. J. Educ. Sci.* **2009**, *1*, 33–37. [CrossRef]
11. Ahmed, W. Developmental trajectories of math anxiety during adolescence: Associations with STEM career choice. *J. Adolesc.* **2018**, *67*, 158–166. [CrossRef]
12. Espino, M.; Pereda, J.; Recon, J.; Perculeza, E.; Umali, C. Mathematics anxiety and its impact on the course and career choice of Grade 11 students. *Int. J. Educ.* **2017**, *2*, 99–119.
13. Hembree, R. The Nature, Effects, and Relief of Mathematics Anxiety. *J. Res. Math. Educ.* **1990**, *21*, 33–46. [CrossRef]
14. Hurst, M.; Cordes, S. When being good at math is not enough: How students' beliefs about the nature of mathematics impact decisions to pursue optional math education. In *Understanding Emotions in Mathematical Thinking and Learning*; Eligio, U.X., Ed.; Elsevier Academic Press: Cambridge, MA, USA, 2017; pp. 221–241. [CrossRef]
15. Meece, J.L.; Wigfield, A.; Eccles, J.S. Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *J. Educ. Psychol.* **1990**, *82*, 60. [CrossRef]
16. Suinn, R.M.; Taylor, S.; Edwards, R.W. Suinn Mathematics Anxiety Rating Scale for Elementary School Students (MARS-E): Psychometric and Normative Data. *Educ. Psychol. Meas.* **1988**, *48*, 979–986. [CrossRef]
17. Harari, R.R.; Vukovic, R.K.; Bailey, S.P. Mathematics Anxiety in Young Children: An Exploratory Study. *J. Exp. Educ.* **2013**, *81*, 538–555. [CrossRef]

18. Jameson, M.M. The Development and Validation of the Children's Anxiety in Math Scale. *J. Psychoeduc. Assess.* **2013**, *31*, 391–395. [CrossRef]
19. Ramirez, G.; Chang, H.; Maloney, E.A.; Levine, S.C.; Beilock, S.L. On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *J. Exp. Child Psychol.* **2016**, *141*, 83–100. [CrossRef]
20. Ganley, C.M.; McGraw, A.L. The Development and Validation of a Revised Version of the Math Anxiety Scale for Young Children. *Front. Psychol.* **2016**, *7*, 1181. [CrossRef]
21. Pletzer, B.; Kronbichler, M.; Enuerk, H.-C.; Kerschbaum, H.H. Mathematics anxiety reduces default mode network deactivation in response to numerical tasks. *Front. Hum. Neurosci.* **2015**, *9*, 202. [CrossRef]
22. Sokolowski, H.M.; Ansari, D. Who Is Afraid of Math? What Is Math Anxiety? And What Can You Do about It? *Front. Young Minds* **2017**, *5*, 1–7. [CrossRef]
23. Young, C.; Wu, S.S.; Menon, V. The Neurodevelopmental Basis of Math Anxiety. *Psychol. Sci.* **2012**, *23*, 492–501. [CrossRef] [PubMed]
24. Ashcraft, M.H.; Kirk, E.P. The relationships among working memory, math anxiety, and performance. *J. Exp. Psychol. Gen.* **2001**, *130*, 224–237. [CrossRef]
25. McDonough, I.M.; Ramirez, G. Individual differences in math anxiety and math self-concept promote forgetting in a directed forgetting paradigm. *Learn. Individ. Differ.* **2018**, *64*, 33–42. [CrossRef]
26. Maloney, E.A.; Ramirez, G.; Gunderson, E.; Levine, S.C.; Beilock, S.L. Intergenerational Effects of Parents' Math Anxiety on Children's Math Achievement and Anxiety. *Psychol. Sci.* **2015**, *26*, 1480–1488. [CrossRef]
27. Ruark, A. Expressive Writing as an Intervention for Math Anxiety in Middle School Students. *MLET J. Middle Level Educ. Tex.* **2021**, *7*, 1.
28. Hines, C.L.; Brown, N.W.; Myran, S. The effects of expressive writing on general and mathematics anxiety for a sample of high school students. *Education* **2016**, *137*, 39–45.
29. Mesghina, A.; Richland, L.E. Impacts of expressive writing on children's anxiety and mathematics learning: Developmental and gender variability. *Contemp. Educ. Psychol.* **2020**, *63*, 101926. [CrossRef]
30. Henslee, A.M.; Klein, B.A. Using brief guided imagery to reduce math anxiety and improve math performance: A pilot study. *J. STEM Educ.* **2017**, *18*, 32–36.
31. Samuel, T.S.; Warner, J. "I Can Math!": Reducing Math Anxiety and Increasing Math Self-Efficacy Using a Mindfulness and Growth Mindset-Based Intervention in First-Year Students. *Community Coll. J. Res. Pract.* **2019**, *45*, 205–222. [CrossRef]
32. Hardy, M. *Interventions and Supports to Ameliorate Math Anxiety in K-12 Schools: A Meta-Analysis of Experimental Group Design Research (Order No. 28353639)*; Brigham Young University: Provo, UT, USA, 2020.
33. Dehaene, S. *The Number Sense: How the Mind Creates Mathematics*; OUP USA: New York City, NY, USA, 2011.
34. Katz, I.; Eilot, K.; Nevo, N. "I'll do it later": Type of motivation, self-efficacy and homework procrastination. *Motiv. Emot.* **2013**, *38*, 111–119. [CrossRef]
35. Paechter, M.; Macher, D.; Martskvishvili, K.; Wimmer, S.; Papousek, I. Mathematics Anxiety and Statistics Anxiety. Shared but Also Unshared Components and Antagonistic Contributions to Performance in Statistics. *Front. Psychol.* **2017**, *8*, 1196. [CrossRef] [PubMed]
36. Okoiye, O.E.; Okezie, N.E.; Nlemadim, M.C. Impact of academic procrastination and study habit on expressed mathematics anxiety of junior secondaryschool students in Esan South-East Edo State Nigeria. *Br. J. Psychol. Res.* **2017**, *5*, 32–40.
37. Bandura, A. *Self-Efficacy: The Exercise of Control*; W. H. Freeman: New York, NY, USA; Times Books: New York, NY, USA; Henry Holt Co.: New York, NY, USA, 1997.
38. Ajzen, I. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *J. Appl. Soc. Psychol.* **2022**, *32*, 665–683. [CrossRef]
39. Lefcourt, H.M. *Locus of Control*; Academic Press: Cambridge, MA, USA, 1991.
40. Bong, M.; Skaalvik, E.M. Academic self-concept and self-efficacy: How different are they really? *Educ. Psychol. Rev.* **2003**, *15*, 1–40. [CrossRef]
41. Spillane, J.P.; Reiser, B.J.; Reimer, T. Policy Implementation and Cognition: Reframing and Refocusing Implementation Research. *Rev. Educ. Res.* **2002**, *72*, 387–431. [CrossRef]
42. Ciarrochi, J.; Chan, A.Y.C.; Bajgar, J. Measuring emotional intelligence in adolescents. *Personal. Individ. Differ.* **2001**, *31*, 1105–1119. [CrossRef]
43. Joseph, D.L.; Newman, D.A. Emotional intelligence: An integrative meta-analysis and cascading model. *J. Appl. Psychol.* **2010**, *95*, 54–78. [CrossRef]
44. Mavroveli, S.; Petrides, K.V.; Sangareau, Y.; Furnham, A. Exploring the relationships between trait emotional intelligence and objective socio-emotional outcomes in childhood. *Br. J. Educ. Psychol.* **2009**, *79*, 259–272. [CrossRef]
45. Kirk, B.A.; Schutte, N.S.; Hine, D.W. Development and preliminary validation of an emotional self-efficacy scale. *Personal. Individ. Differ.* **2008**, *45*, 432–436. [CrossRef]
46. Qualter, P.; Pool, L.D.; Gardner, K.J.; Ashley-Kot, S.; Wise, A.; Wols, A. The emotional self-efficacy scale: Adaptation and validation for young adolescents. *J. Psychoeduc. Assess.* **2015**, *33*, 33–45. [CrossRef]
47. Muris, P. A Brief Questionnaire for Measuring Self-Efficacy in Youths. *J. Psychopathol. Behav. Assess.* **2001**, *23*, 145–149. [CrossRef]

48. Mayer, J.; Salovey, P.; Caruso, D.R. Emotional Intelligence: Theory, Findings, and Implications. *Psychol. Inq.* **2004**, *15*, 197–215. [CrossRef]
49. Caprara, G.V.; Gerbino, M. Affective perceived self-efficacy: The capacity to regulate negative affect and to express positive affect. In *Self-Efficacy Assessment*; Caprara, G.V., Ed.; Edizioni Erickson: Trento, Italy, 2001; pp. 35–50.
50. Caprara, G.V.; Di Giunta, L.; Eisenberg, N.; Gerbino, M.; Pastorelli, C.; Tramontano, C. Assessing regulatory emotional self-efficacy in three countries. *Psychol. Assess.* **2008**, *20*, 227–237. [CrossRef] [PubMed]
51. Muris, P. Relationships between self-efficacy and symptoms of anxiety disorders and depression in a normal adolescent sample. *Pers. Individ. Differ.* **2002**, *32*, 337–348. [CrossRef]
52. Wigelsworth, M.; Qualter, P.; Humphrey, N. Emotional self-efficacy, conduct problems, and academic attainment: Developmental cascade effects in early adolescence. *Eur. J. Dev. Psychol.* **2016**, *14*, 172–189. [CrossRef]
53. Bandura, A.; Pastorelli, C.; Barbaranelli, C.; Caprara, G.V. Self-efficacy pathways to childhood depression. *J. Pers. Soc. Psychol.* **1999**, *76*, 258–269. [CrossRef]
54. Bandura, A.; Barbaranelli, C.; Caprara, G.V.; Pastorelli, C. Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Dev.* **2001**, *72*, 187–206. [CrossRef]
55. Jameson, M.M.; Fusco, B.R. Math Anxiety, Math Self-Concept, and Math Self-Efficacy in Adult Learners Compared to Traditional Undergraduate Students. *Adult Educ. Q.* **2014**, *64*, 306–322. [CrossRef]
56. Lee, J. Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learn. Individ. Differ.* **2009**, *19*, 355–365. [CrossRef]
57. Palestro, J.J.; Jameson, M.M. Math self-efficacy, not emotional self-efficacy, mediates the math anxiety-performance relationship in undergraduate students. *Cogn. Brain Behav. Interdiscip. J.* **2020**, *24*, 379–394. [CrossRef]
58. Muris, P.; Mayer, B.; van Lint, C.; Hofman, S. Attentional control and psychopathological symptoms in children. *Pers. Individ. Differ.* **2008**, *44*, 1495–1505. [CrossRef]
59. Galla, B.M.; Wood, J.J. Emotional self-efficacy moderates anxiety-related impairments in math performance in elementary school-age youth. *Pers. Individ. Differ.* **2012**, *52*, 118–122. [CrossRef]
60. Fenwick, T.; Edwards, R.; Sawchuk, P. *Emerging Approaches to Educational Research: Tracing the Socio-Material*; Routledge: Abdington, UK, 2015.
61. IXL Learning. 2016. Available online: www.ixl.com (accessed on 1 September 2022).
62. Cartwright, M.; Kloos, H.; Mano, Q.R.; Hord, C. Child-guided math practice: The role of regulatory emotional self-efficacy for children experiencing homelessness. *CogSci* **2018**, *1*, 1452–1457.
63. Namkung, J.M.; Peng, P.; Lin, X. The Relation Between Mathematics Anxiety and Mathematics Performance Among School-Aged Students: A Meta-Analysis. *Rev. Educ. Res.* **2019**, *89*, 459–496. [CrossRef]
64. Barroso, C.; Ganley, C.M.; McGraw, A.L.; Geer, E.A.; Hart, S.A.; Daucourt, M.C. A meta-analysis of the relation between math anxiety and math achievement. *Psychol. Bull.* **2021**, *147*, 134–168. [CrossRef]