Child-guided math practice: The role of regulatory emotional self-efficacy for children experiencing homelessness

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Abstract

A child's perceived ability, over and above actual ability, matters for various behavioral outcomes, academic or personal. In the current paper, we looked at one type of self-efficacy: children's perceived ability to regulate their own negative emotions. Our question was whether regulatory emotional self-efficacy (RESE) affects math learning for children who are faced with homelessness. The specific math enrichment centered on child-guided math practice: Children were given a commercially available app and encouraged to pick out their own practice problems. Our thought was that RESE might affect children's learning when they are given a chance to determine their own math-practice path. The goal of the current study was to establish this link empirically. The sample included 5- to 12-year-olds who attended a summer program organized for homeless children. Results confirmed our hypothesis. Children who scored lowest on the RESE scales ($N = 40$) benefited less from the math practice than children who scored highest ($N = 46$). Specifically, the improvement in math was correlated with number of practice sessions only for high-RESE children, not for low-RESE children. These results suggest that RESE is an important factor in learning math, to be considered when developing student-centered pedagogy.

Keywords: learning; math competence; homelessness; summer camp

Introduction

Math is a subject that many children find difficult to master. Even thinking about math can cause children to experience negative emotions (Wigfield & Meece, 1988). Therefore, it is likely that regulatory emotional self-efficacy (RESE) plays an important role in how children learn math. If children do not believe that they can manage their negative emotions, they are not likely to respond well when faced with a difficult math problem. The population of children in the current study are experiencing homelessness and attending a summer enrichment camp. As a result, they are at a higher risk of math difficulty and low RESE than their housed peers, adding to the troubles. In the current paper, we investigate the role of RESE in how these children respond to child-guided math practice. In what follows, we will first discuss the nature of math and why child-guided practice is necessary. We will then consider the importance of RESE.

A Model of Math Learning

Because math is persistent and cumulative, it becomes easy for children to get left behind early. When the material advances quicker than children are able to comprehend, they continue to fall further behind. For example, soon after children are introduced to numerical quantities and counting, they are expected to learn addition, where an ability to count is crucial. Beyond that, addition is nested within multiplication, so if addition is not understood, multiplication is much more difficult to understand and execute.

The material in the classroom moves at a quick pace: by the end of third grade children are expected to multiply whole numbers, and by the end of fifth grade they are expected to multiply fractions. Add to that all of the underlying concepts necessary to understand multiplication and fractions, and children can easily become overwhelmed, particularly those who are already struggling. Without proficiency in underlying concepts, a child is likely to struggle with multiplication of fractions when this topic is introduced through formal classroom instruction. In turn, this could potentially render formal instruction ineffective, leaving the child with little more knowledge than they entered with.

The importance of math may not be explicitly evident to children, and its purpose can easily be misconstrued as arbitrary. Even children who excel at the subject are not likely to be interested in seeking out math content during summer months, let alone children who fell behind. In contrast, exposure to reading material can be more enjoyable for children. They can choose to read what they like, so reading practice can relate to any range of interests they may have. This is not necessarily true of math, which is limited in what practice can pertain to that is commonly of interest to children. In addition, math practice is not as easily carried out when compared to reading practice. For reading, there are public libraries that provide free books, and 70% of parents interviewed in a 2013 report claimed to have taken their child(ren) to a library within the past year, 87% of those visits resulted in the child checking out a book (Pew Research Center, 2013). No such opportunities are publicly available for math practice, leaving caregivers with the options of paying for math enrichment programs or taking the time to developing practice problems and deliver feedback on their own. Neither of these options are likely to be feasible for parents of low-income households.

During the school year, students often sit in a large classroom with many other students; they receive the same instruction in the same environment from the same teacher. This has the advantage of being low-cost: typically, free for the families, and of minimal cost to the school. It also ensures uniformity, that each child is given the same information. Therefore, much research is invested in what teaching strategies and curriculum are most effective (National Mathematics Advisory Panel, 2008). However, there are a multitude of factors that differ among students that contribute to their differences in mathematical abilities, and those who perform the lowest can easily be overlooked. With many classrooms reaching 30 or more students, it can be a difficult feat to address and account for each individual student's strengths and weaknesses in an instructional setting.

An individualized approach is an alternative option that might better account for each students' abilities (Horak, 1981). While it is clear that students who are behind need to catch up, they cannot easily do so by learning the more advanced topics at the ability of some of their peers. Whole-class instruction, where a larger group of children are taught by a single person delivering a lesson to the entire group, has the disadvantage of neglecting children who have fallen behind. Specifically, whole-class math instruction can be problematic for children from low-SES communities who are more likely to be low-achieving and lack the most resources outside of school. Further, Klem & Connell (2004) have stressed the importance of personalization in learning environments, where the students feel that they are supported by the teacher. With this support comes a level of individualization for the teacher to fully engage with each student.

Technology-based interventions are a promising way to carry out individualized approaches. These are typically designed so that children can work on math appropriate for their skill level, they are engaging by allowing children to work toward a goal, and they provide immediate feedback (Gross & Duhon, 2013). One commonly used intervention is called "Math Facts in a Flash" (MFF). MFF is designed to improve math fluency and automaticity on the four basic operations. It is a computer-based software, hierarchically organized so that children must master a level before moving on to the next (Burns, Kanive, &DeGrande, 2010). MFF has been effective for improving elementary school children's performance regardless of their skill level, and in some cases with significantly fewer children rendered at-risk for math failure at the end of the intervention (Burns et al., 2010). Another computer-based math intervention that led to improved math performance had children practice math at their own level at home on a computer game for 15 minutes each day (Kucian et al., 2011). Beyond improvements in math performance, math programs that utilize tablets specifically are beneficial for positive self-perceptions, self-efficacy, and increased motivation (Hilton, 2016).

The Importance of RESE

Emotional intelligence is a term used to describe the ability to regulate emotions and navigate information regarding emotions (Mayer, Salovey, & Caruso, 2004). Studies have demonstrated that emotional intelligence has a positive relationship with academic success (Chew, Zain & Hassan, 2013). For example, it has an effect on performance on cognitive tasks, above and beyond that of general intelligence (Lam & Kirby, 2002). Regulatory emotional self-efficacy (RESE) is defined as the perceived ability to regulate one's own negative emotions.

General self-efficacy, or perceived control over one's situation, plays an important role in well-being (Bandura, 1997). Without confidence in one's own abilities, there would be no incentive to push through barriers and persist in achieving an outcome. If an individual questions whether his or her actions will affect an outcome, even the smallest challenge is likely to become a deterrent (cf., Ajzen, 2002). Self-efficacy affects the perception of roadblocks, which, in turn, affects the degree of persistence and resilience (Spillane, Reiser, & Reimer, 2002). Thus, perceived competence has its own value in well-being, over and above actual competence.

Math is challenging for many children, which can lead to negative emotions. During child-guided practice, if a child chooses a problem that is too difficult, the emotions that follow direct their decisions about future practice. For example, if a child with high RESE chooses math that is too difficult, causing him or her to become frustrated, he or she may recognize those feelings and use the opportunity to switch to math at a more appropriate level of difficulty. On the contrary, if that child with low RESE chooses math that is too difficult and becomes frustrated, he or she may become overwhelmed and discontinue practice altogether. This might also affect their willingness to participate in the future.

Overview of the current study

It is possible that RESE is an important factor in how a child practices math. The potential link between RESE and math practice is particularly interesting when considering the complications that homelessness presents. In this study, we seek to investigate how children experiencing homelessness respond to child-guided math practice as a function of their RESE. During a 7-week summer day camp, children engaged in practice sessions several times a week. During a typical session, children used the IXL app on a touchscreen tablet for 40 minutes, and facilitators worked in small groups of two to four children. Math competence was assessed via two measures: math fluency and math comprehension. RESE was assessed via a survey (Canfield, Cartwright, Kloos, Schmerr, & Aigner, 2018). We predict that more practice will be correlated with an improvement in math comprehension for children with high RESE, but not for children with low RESE.

Method

Sample

Children included in this study were 182 elementary-school children who attended the summer camp, ages 5-13 years (*M* = 8.93, *SD* = 2.14). Overall, 44.50% of the children were girls, 50% were African-American and 38.46% were Caucasian. They met the guidelines for experiencing homelessness according to the non-profit group that organized the summer camp. Participation in the camp was free to the children, and they were provided with transportation, as well as two meals.

Summer Camp

The summer camp was held at two different sites (A and B), five days per week, for seven consecutive weeks. There were three groups of children, loosely organized by the grade level children entered after the summer. The demographics of children in each of the groups are reported in Table 1, broken down by site. Academic enrichment was offered during the mornings (9 AM -12 AM), and child-guided practice took place during some part of that time. Specifically, practice was offered three times a week at Site A and one time a week at Site B. Each practice session lasted approximately 40 minutes. Children occasionally received additional math lessons, not in conjunction with the child-guided practice, by a certified teacher during the additional day of academic enrichment.

Table 1: Demographics of the summer camp, organized by age, group, and site.

	Group 1 (Grades 1-2)		Group 2 (Grades 3-4)		Group 3 (Grades 5-6)	
	Site A	Site B	Site A	Site B	Site A	Site B
N	18	45	17	34	20	48
Age in years						
M (*SD*)	6.52(.69)	6.63(1.04)	8.53(.88)	8.89(.63)	11.29(.82)	11.14(1.00)
Gender (%)						
Female	33.33	46.67	52.94	47.06	45.00	41.67
Race (%)						
African-American	11.11	68.89	5.88	85.29	5.00	56.29
Caucasian	66.76	26.67	82.35	8.82	75.00	29.17
Biracial	22.22	4.44	11.76	2.94	2.00	10.42

Facilitators

College students were recruited to serve as facilitators, with approximately 6-7 in attendance during each session. They were given a brief 10-minute training that discussed their role in the program, and additional coaching was provided onsite. Facilitators were discouraged to explain a math concept or procedure to the child. Feeling the urge to do so anyway could serve as a sign that the child is working on a problem set that is too difficult. Rather than explaining math to children, children should be encouraged to switch to something easier. In contrast, if a child was growing bored and unengaged because the problem set was too easy, the facilitator should suggest a more difficult problem set. The monitoring and modulating of problem difficulty were central to the program and thus was encouraged throughout.

Materials

Math practice app. IXL organizes problems pursuant to the common core by grade level, math topic, and specific variations within a math topic. A problem set is one of those variations (e.g., multiplication tables up to 12), nested within a topic (e.g., multiplication fluency), which is nested within a grade level (3rd grade). A problem set presents individual problems one at a time in a simple format, free from distracting colors and designs. After a correct answer, the child is greeted by simple positive feedback (i.e., "Fantastic"), awarded points, and then presented with the next problem. After an incorrect answer, a few points are deducted, the child is given the correct answer and a suggestion for how to solve the problem. They can easily click to move on to the next problem (with or without reading the explanations). Point progress is displayed as a bar at the top of the screen, with a goal of 100 points per problem set.

Curriculum matrix. A unique matrix was created for each age group. Matrices were strategically designed to include a range of six or seven topic domains that corresponded with the common core for relevant grade levels. Specifically, for Group 1, the domains were: counting, patterns, addition, subtraction, word problems, and fractions. For Group 2, the domains were: counting, addition, subtraction, word problems, fractions, multiplication, and division. Finally, for Group 3, the domains were: addition/subtraction, word problems, fractions, multiplication, division, decimals, and pre-algebra. Within each topic, there were several levels of difficulty. Each cell of the matrix referenced specific problem sets in IXL so that children and facilitators could easily find appropriate practice problems that fit the child's skill level.

Measures

Math fluency. The standardized T_{10} subtest from Version IV of the Woodcock-Johnson test battery was used to capture a child's math fluency. It is a two-page 3-minute timed test, comprised of single-digit addition, subtraction, and multiplication problems.

Math comprehension. Math comprehension was assessed using an existing readiness test (Excel Math curriculum), modified slightly. Specifically, Group 1 received the readiness test for 1st and 2nd grade; Group 2 received the readiness test for 3rd and 4th grade; and Group 3 received the readiness test for 5th and 6th grade. We also added a set of fraction problems to supplement the tests. Each group received 4-9 fraction problems, with increasing difficulty, reflecting the grade-specific fraction problems in IXL.

Regulatory emotional self-efficacy survey. An eight-question survey was used to capture a child's perceived ability to manage their own emotions. Specifically, it consisted of questions directed at a child's ability to control negative emotions such as "I know how to calm myself down when I get scared" and "I know how to make myself feel better when I start worrying about something." Children responded on a 5-point Likert-scale, ranging from strongly disagree to strongly agree.

Procedure of Data Collection and Scoring

Math fluency. Children were assessed on the math fluency measure during the first and last week of the camp. It was administered by a researcher to the entire classroom, while facilitators enforced the procedures in small groups. Children were instructed to start on the first page, answer as many questions as they could during the 3-minutes, and skip any that they did not know. The raw score was calculated as a number of how many questions were answered correctly.

Math comprehension. Children were assessed on the math comprehension measure during the first and last week of camp. Similar to the math fluency test, it was administered by a researcher to the entire class, while facilitators enforced the procedures in small groups. Children were instructed to complete only the problems they liked, and if they did not like a problem, or did not know how to do it, to simply cross the problem out and move on, rather than get too frustrated or overwhelmed. Teachers, volunteers, and facilitators assisted if children had questions, but they did not help with answers. Assessments were scored as a percentage of questions answered correct (e.g., if a child answered 48% of the questions correct, they received a score of 48).

Regulatory emotional self-efficacy. During the first week of camp, the RESE survey was distributed as part of a larger battery of surveys to children. Only children who were present on the given day of testing received the survey. Children who required reading assistance were read each question aloud by a camp staff member or volunteer. RESE was scored as an average of each 1-5 response.

Procedure of a Practice Session

After logging in, facilitators instructed children to begin their practice with a warm-up problem set. These problem sets were designed to be easy and quick, to get all children started on time and actively engaged in math. During the first few weeks, the warm-up problem set was pre-determined by the research team. Children were given a choice between two problem sets of the same topic, and while both were easy, one was slightly more difficult than the other. For the remainder of the weeks, children were encouraged to decide their own warm-up problem. After each child reached 100 points on their warm-up problem, they earned a small piece of candy.

During the rest of the session, children had the opportunity to determine much of what they practiced themselves. Suggestions were occasionally given and progress was monitored by the facilitators, but children were encouraged to self-guide their own practice. In conjunction with the matrices, the child and facilitator found appropriate problem sets and the child worked largely independently. Five minutes before the end of the session, a prompt was given to the class to finish what they were working on, log out, and put all materials away. Once all of these were completed, the child earned a second piece of candy.

Results

To determine whether child-guided math practice improved children's math competence, we looked at (1) the number of practice problems, (2) children's changes in math fluency, and (3) children changes in math comprehension. Table 2 provides the descriptive statistics of these variables. Using the data from the RESE survey, the children were divided into two groups; children who scored above the mean of 3.95 (SD = 0.80) were placed in the high RESE group (M = 4.52, SD = 0.40), while children who scored below the mean were placed in the low RESE group (M = 3.30, SD = 0.64). When comparing the means of the high and low RESE groups, the results of the Levene's test for homogeneity of variance were significant, F = 7.27, p = .01, so homogeneity was not assumed. An independent samples t-test revealed a significant difference between these two means $t(62.13) = -10.29$, $p < .001$. In the context of these data, the terms *high* and *low* are used relative to the mean of the sample, rather than to indicate high and low on the 1-5 scale (where 3.30 would represent neutral rather than low).

At pre-test, there was no difference in performance between the high- and low-RESE groups on either math fluency (t[74] = .68, p = .50), or math comprehension (t[83] = -.58, p = .56). For children with high RESE, as the number of practice sessions increased, math competence significantly increased from pre- to post-test, including both math fluency (r[40] = .35, p = .02) and math comprehension (r[39] = .39, p = .01). However, for children with low RESE, as the number of practice sessions increased, math competence did not increase, either for math fluency (r[32] = .06, p = .74), or math comprehension (r[34] = .15, p = .38).

Table 2: Descriptive statistics for practice and math competence measures.

	Group 1	Group 2	Group 3
# of sessions			
N	34	35	40
Range	1-20	2-19	0-19
M	9.91	7.94	7.28
(*SD*)	(5.89)	(5.79)	(6.08)
Math fluency*			
N	33	31	33
Pre			
Range	0-43	4-90	27-94
M	11.48	35.61	60.24
(*SD*)	(11.33)	(18.12)	(15.53)
Post			
Range	0-40	6-90	4-102
M	11.24	37.81	58.09
(*SD*)	(10.21)	(20.29)	(21.98)
Math comprehension**			
N	27	28	38
Pre			
Range	2-73	3-69	7-45
M	35.76	29.36	21.89
(*SD*)	(21.97)	(16.61)	(11.10)
Post			
Range	2-93	5-85	4-48
M	44.07	32.57	23.76
(*SD*)	(24.68)	(22.41)	(11.67)

Note. Children who were not assessed both pre- and post-test for the relevant variables were excluded.
*Scored as number of correctly answered problems.
**Scored as a percent of correctly answered problems.

Discussion

Results suggest that there is a relation between personalized math practice and improvement in math competence. Children differed in what topics they practiced, how many questions they answered, and how difficult the problems were. This could imply that exposure to math, regardless of specific content, is important in improving competence. It could help explain why children from low-SES, who have a lack of exposure to math during the summer, experience summer learning loss (Burkham, Ready, Lee, & LoGerfo, 2004). Or, rather, it could mean that the personalized, child-centered approach is what is important. There is some evidence from other studies to suggest that the latter is the case, such as with Math Facts in a Flash (Burns et al., 2010).

Of particular interest is the difference in effect math practice had on math competence for children of different RESE. As a concept, general self-efficacy is derived from social cognitive theory, which states that one's beliefs are an important element to achievement (Bandura, 1997). RESE refers to how one perceives their own ability to regulate their emotions, and the perceived ability to achieve a goal can be thought of as a prerequisite for actualizing the goal (Caprara et al., 2008; Kirk, Schutte, & Hine, 2008). Therefore, a child's belief that they can regulate their emotions is important in their ability to do so successfully. Given the link between RESE, emotional intelligence, and academic success, a logical prediction would be that children with lower RESE would have lower scores at pre-test than their high RESE peers. However, this was not the case for either the measure of math fluency or the measure of math comprehension.

Rather than focusing on a difference in performance at pre-test, this study addresses how RESE might affect the learning that happens as the result of child-guided math practice. What is the potential for children with low RESE to learn through a program or intervention that targets learning gains? Interestingly, results showed that more practice did not lead to an improvement in math competence if a child had low RESE. However, more practice did lead to an improvement in math competence if a child had high RESE. These findings suggest that in order for personalized math practice to be effective, children must enter the program with high RESE.

There are a few possible explanations for this finding. One is that if a child with low RESE is presented with a challenging problem and becomes frustrated or angry, he or she is not prepared to manage those negative emotions appropriately. Therefore, the child might be hindered from learning and continuing through the remainder of the session. Another explanation has been demonstrated empirically: Emotional self-efficacy moderates the negative effects of anxiety on math performance (Galla & Wood, 2012). In the study by Galla & Wood, anxiety was only predictive of math performance in children with low emotional self-efficacy. Children with high emotional-self efficacy showed no effect of anxiety on math performance, inferring that the perceived ability to manage negative emotions protects children from the negative effects of anxiety on math performance. Therefore, while children in the current study were not tested on any anxiety measures, it is possible that children with high RESE were protected from any negative effect that might exist of anxiety on learning. Conversely, it is likely that some children with low-RESE also had low anxiety, ultimately affecting their learning experience.

Limitations

Including the community as a partner in the design of the research can be limiting. Community organizations have concerns to carry out their programs that take priority over the integrity of the research. For example, the differences in demographics between sites are very large. The number of children in Site A is far less than Site B. The racial makeup of Site A is majority Caucasian, while Site B is majority African-American. These details are part of the structure of the summer camp, which is dependent on outside factors and resources. Nonetheless, they are important in considering the findings. Specifically, personalized math practice was only available for children in Site B once per week. Therefore, in correlations that include frequency of practice, children from Site B only represent data points that are low in frequency.

There are many instances in which this project did not follow a strict research protocol. Even though the protocol was designed by the research team and the non-profit organization, it was not always possible to follow it strictly. Because it was carried out in the community, the protocol was left flexible. In some instances, children were particularly stubborn in refusing to practice predetermined math topics, measures were not always appropriate for all children (i.e., children with disabilities that impaired writing), not enough facilitators were available to work in predetermined facilitator-to-child ratios, or the camp was scheduled for activities that interfered with the regular sessions. In these instances, accommodations were made so as to benefit the child, the non-profit organization, and the research as best as possible, without disregarding any one in particular.

Conclusions

Child-guided math practice was most beneficial when children had high RESE. This finding posits valuable questions for future research: Is there a way to improve children's emotional self-efficacy? Or rather, is there a way to structure practice to prevent the child from choosing math problems that can cause overwhelming emotions? It is possible that restricting the child's ability to guide their practice will only exacerbate the problem.

A lack of improvement in math performance must be considered in the context of a summer program. Generally, it is expected that children decline in math performance over the course of the summer (Cooper et al., 1996). Therefore, they should experience a portion of that decline between the beginning and the end of a 7-week camp. On average, children retained or improved their math performance more often than they did not (see Table 2), which is an accomplishment relative to the expected decline.

Acknowledgments

This material is based upon work supported by an NSF Graduate Research Fellowship awarded to MC (#1000221730) and by a University of Cincinnati grant awarded to HK. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funders. We would like to thank Upspring for providing us with their program data.

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