

# “Mental Math”: Building coping and problem-solving skills in math class.

## Abstract

Many youth face mental health obstacles to their learning and wellbeing. School, and especially math class, is an overlooked and underutilized arena for students to learn coping and problem-solving skills and apply them to both academic and broader life challenges. A brief online intervention, Mental Math, developed with cognitive-behavioral principles, had high engagement and significant positive effects on academic performance among high school math students. Implications for future implementation are discussed.

*Keywords: coping, problem-solving, math anxiety, mental health, social and emotional learning, online intervention, high school*

## Introduction

Up to 20% of children aged 3 to 17 in the United States have a reported mental, emotional, or behavioral disorder, and about half of those do not receive adequate treatment each year (OSG, 2021). Schools can serve as accessible and practicable settings to teach and foster students' skills related to mental health and wellbeing. American schools have always served as more than places of academic learning, from their religious origins to the Deweyan civic ethos to student athletics and clubs today (Urban & Wagoner, 2014). Students develop their sense of self and build their individual and social competencies among their peers at school.

In May and June of 2020, although half of students identified depression, stress, and anxiety as obstacles to online learning, only 54% of districts

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surveyed were providing mental health support, and less than 10% were measuring student wellbeing (DeArmond et al., 2021). In addition, according to a 2020 meta-analysis, schools provide mental health services for about 7.3% of the general youth population and 22% of youth with elevated mental health symptoms or diagnoses, which are only slightly higher rates than outpatient settings (Duong et al., 2020). These rates are despite school professionals having access to nearly all children on a day-to-day basis.

Schools are good candidates for social and emotional learning (SEL); however, valuable skills like empathy, social problem-solving, and coping with challenges are not universally taught. While these rates are increasing, only 53% of teachers and 76% of principals reported that their schools used SEL programs or materials at least “sometimes” in the 2021-2022 school year (Schwartz et al., 2022). Furthermore, the most common schoolwide SEL activity is supportive discipline, and not explicit skill training or integration into classroom learning (Schwartz et al., 2022). Altogether, these data indicate that SEL skills are far from being taught in most classrooms or to most students.

Math class is an overlooked arena for a student to learn certain coping and problem-solving skills, apply them to academic challenges, and extend them to their own life. Proficiency in math requires students to “make sense of problems and persevere in solving them” (Ohio DOE, 2017). The structure and rules inherent to mathematics provide scaffolding and support: a contained place for students to learn to solve problems and cope with setbacks. These lifelong lessons are applicable to a myriad of challenges.

Furthermore, math class is particularly appealing because it allows for acquisition and practice of skills in a setting where anxiety is likely to be present. Approximately 30% of adolescents are affected by math anxiety, which inhibits both math content intake and performance (Moustafa et al., 2021). Math anxiety stems from negative experiences in math and is tied to emotional dysregulation, paving the way for other anxieties, distress, and dysfunction

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(Moustafa et al., 2021). Furthermore, math anxiety is associated with decreased academic performance, academic self-concept, motivation to learn, and pursuit of STEM careers (Moustafa et al., 2021; Asanjarani & Zarebaramabadi, 2021).

Some research indicates that math anxiety can be addressed with directed intervention. In one study, a cognitive-behavioral intervention involving psychoeducation, cognitive restructuring, relaxation, and graded exposure reduced anxiety symptoms in students with elevated levels of math anxiety (Asanjarani & Zarebaramabadi, 2021). In another study, a 16-session counseling program focused on SEL competencies reduced math anxiety in a non-clinical group of middle school students (Kamour & Altakhayneh, 2021). In general, SEL programs have well-established beneficial effects on both academic performance and mental health (Durlak et al., 2022).

It may not be practical to implement a full-length SEL program, so classroom-level changes and brief interventions are other possibilities. Elements of mindfulness, relaxation, self-reflection, and building a growth mindset can be incorporated into math classrooms to decrease anxiety (RELNW, 2017). Resources exist for implementing SEL practices in math class (e.g. Inside Mathematics, 2023; Vorensky, 2023), but their efficacy is untested. Outside of the classroom, enrichment experiences like math clubs can build problem-solving skills and stave off math anxiety (Flick & Kuchey, 2022). Learning the coping strategies to address math anxiety in particular can address other anxiety issues and mental health in general while the academic context can reduce the associated stigma and boost grades.

## **Mental Math Intervention**

The first author developed a brief intervention to build emotional awareness and cognitive restructuring skills in an Ohio high school math class. The intervention, “Mental Math,” was developed at an Ohio university as part of

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the first author’s secondary education coursework (Lower, 2018) and tested while the first author was a student teacher. The present iteration of Mental Math was approved by the school’s math department and implemented in Spring 2022 as a self-guided online homework assignment. The full text is available in the Appendix. The intervention’s content included concepts from cognitive-behavioral therapy (e.g. emotional labeling, thought replacement, and problem-solving). The intervention had eight free-response and matching questions for a total possible score of 20 points. Written feedback was solicited in the last question. In this pilot study, there were no explicit measures of math anxiety or mental health, but completion, engagement, and academic results were observed.

Descriptive statistics were executed to describe the sample. Independent samples t-tests were run to examine differences in students’ exam grades and final course grades, comparing students who completed the intervention to students who did not. Pearson’s correlations were used to understand relationships between variables of interest. Results were further examined by specifically analyzing students with certain minimum grades or scores as a means of controlling for floor effects.

Of the 126 students with recorded grades, 83 students (66%) completed Mental Math by submitting the finished assignment. Students who submitted Mental Math showed significantly more improvement from the exam prior to Mental Math to the exam after Mental Math than those who did not submit the assignment,  $t(80)=3.173$ ,  $p<0.01$ . This association was maintained when including only students with nonzero exam scores,  $t(78)=2.52$ ,  $p<0.05$ . Furthermore, among the 77 students (61%) with a final course grade over 50%, score on Mental Math was positively correlated with exam score improvement,  $r(77)=0.458$ ,  $p<0.001$ , and final course grade,  $r(77)=0.297$ ,  $p<0.01$ .

Students who completed Mental Math were highly engaged with the assignment, with 75 students (91%) answering every question. Specifically,

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students came up with an average of 14.4 feeling words for emotional labeling (Question 1; range 4-80) and 3.4 broken chair uses for problem-solving (Question 4; range 0-7). Also, students performed very well on the objective thought replacement matching exercise, scoring an average of 6.48 out of 7 (Question 6; SD 1.12).

Feedback was mostly positive (78%) with some mixed/neutral (12%) or negative (9%). Four students (5%) wrote about not feeling comfortable with discussing their feelings or being asked to do so in a math class:

- *Throughout this assignment I felt like I was writing about things I didn't feel comfortable talking about.*
- *I did not like this assignment because it made me feel like I was in English or psychology class.*

Other students enjoyed the expressive and reflective aspects of the assignment and found its techniques helpful:

- *What seemed the most helpful was turning these negative thoughts and feelings into inspiration.*
- *I honestly loved this assignment. It gave me a chance to express how I feel.*
- *It's good to challenge your brain by formulating opinions.*
- *Doing this assignment I've learned more about myself.*
- *I got frustrated and wanted to give up but I like how it helped my solving skills and helped me get over my fear of asking for help.*
- *I enjoyed the aspect of using ways to help make our brains less negative into helping our frustrations with math.*

## **Conclusion**

The brief online Mental Math intervention had high engagement and significant positive effects on academic performance among high school math students. These math performance effects were found not only in subsequent

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exam improvement but final course grade. To the authors’ knowledge, this is the first empirical study of a single-session or online mental health intervention set in a math class.

While promising, these results are limited by lack of controls and absence of validated measures of mental health. Replication in other settings can solidify the feasibility and utility of this intervention. Students need to know that they may experience uncomfortable feelings in the course of the intervention and be prepared for that. Earlier iterations of Mental Math included a relaxation component which was removed for this online implementation; it may be worth reinstating as other programs have included relaxation (e.g. Asanjarani & Zarebaramabadi, 2021).

The feedback to Mental Math indicates a need to normalize the discussion of coping with challenges in class beforehand without forcing students to overshare. However, it seemed that the self-help nature of the assignment was liberating to many students. It was anticipated that working on mental health skills in the setting of a math class and initially applying them to coping with difficulties in math would lessen the stigma connected to mental health, so the overall positive feedback is encouraging.

There are plenty of strong ideas on how to promote coping and problem-solving skills in math class, from cultivating a growth mindset (e.g. Boaler et al., 2021) to altering the Algebra 1-Geometry-Algebra 2 sequence in favor of a data fluency curriculum (e.g. Dubner & Levitt, 2019). However, it remains that these skills are as vital in math class as they are in everyday life, and the former can provide an incubator to hone the skills for the latter.

At present, mental health support and assessment are severely lacking for youth, and avenues outside of traditional therapy need to be considered (Kazdin, 2019). School-based mental health promotion can mitigate obstacles of stigma, time constraint, and lack of access while being conducted in an environment that encourages the learning and practice of life skills (Bodicherla

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et al., 2021). The Ohio Department of Education endorses K-12 SEL standards, but does not offer tools for the learning or testing of those standards on the state level (Ohio DOE, 2019). Instead, educators, school administrators, counselors, and researchers need to collaborate to develop engaging and applicable interventions and classroom practices with objective measures of performance, engagement, and health. Building these skills in the conducive and accessible environment of math class can promote mental wellbeing as well as academic achievement for young people.

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## Appendix

### Mental Math (Self-Guided Online Version)

#### First Page

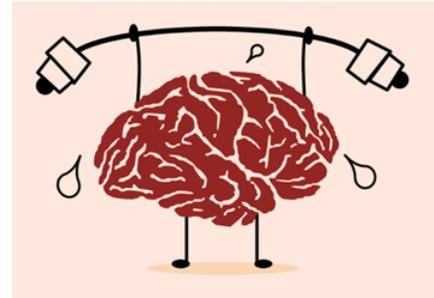
**Welcome to Mental Math! Read carefully and answer each question fully for credit.**

Hello. This quiz will not focus on specific math skills - we've got the CPs for that. Instead, it will focus on the coping and problem-solving strategies that we use all the time in school and in life.

I've adapted this lesson from a classroom to a Canvas quiz, so read the questions carefully and think about them honestly. If something is upsetting or tough to process, then take a break before returning.

Your responses will be graded for completion rather than content. That does not mean you can blow off this assignment. I will be reading what you write. It's okay to not share what doesn't feel comfortable.

I hope that you leave this assignment feeling like you just left the gym: tired but satisfied at having built up your mental strength and skills.



#### Question 1

For the next two minutes, create a set of **feeling words** - words to describe feelings and emotions - the more specific, the better. "Happy" and "sad" are a solid start, but vague. List words that your English teacher would be proud of. Write as many strong, specific feeling words as you can in two minutes.

FEELING WORDS:


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### Question 2

Look at your list of words above.

Which are your favorites?

Which do you feel when confronted by a challenge, like a hard math problem?

Do those words describe "bad" feelings?

### Question 3

Broken chair exercise, part 1.

Consider the chair to the right.

This chair has a loose leg. It looks okay, but as soon as someone sits in the chair, the leg will give out and the chair will collapse.

Answer the following questions:

- Is this a broken chair?
- Does this chair fill its purpose as a chair?
- Is this a good chair?



### Question 4

Broken chair exercise, part 2.

Consider the same chair with the loose leg.

Think - and then write - about how this particular chair might be useful. What can you do with this chair that you can't do with a "good" chair?

Maybe this chair would be useful in a prank. Maybe it would be helpful to someone who's learning carpentry. Maybe it makes good firewood!

Come up with several examples - the more creative, the better.



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### Question 5

Good work with the chair examples! Now consider the following quote:

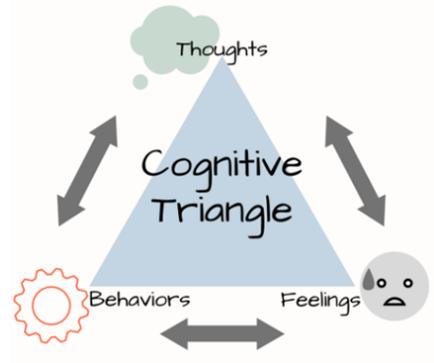
"Thoughts and feelings are neither good or bad, true or false. They are either harmful or helpful." —Dr. Jason Satterfield.

Look back up at your list of feeling words. What you did - **labeling feelings** - is a powerful strategy for catching yourself in a cycle of hurtful feelings leading to hurtful thoughts and actions, as in the Cognitive Triangle to the right.

Our next strategy is **thought replacement**.

- Pick one of the feeling words that you feel when confronted by a challenge and that you think labels a "bad" feeling.
- Consider the thought that feeling brings on. What do you think about yourself and your ability when you feel that way?
- Think - and then write - about how that "bad" feeling could instead, somehow, be helpful to you.
- For example, if you feel *frustrated* by a problem, maybe that frustration is helpful as an indicator that you need to try a new strategy.

This is tough! Give it some time. If the first thought doesn't work, then try the next. You can do it.



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### Question 6

[Options below are shown paired with match.]

Thought replacement exercise.

Match each harmful thought on the left with the most relevant helpful thought on the right.

Each will only be used once.

For example: "I'm bad at math." → "I haven't mastered this part of math yet."

I'm bad at math.		I haven't mastered this part of math yet.
This is boring.		I haven't found a way to make this interesting yet.
This is useless.		I haven't found a way to make this useful yet.
I'm stuck.		I may need help finding the next step.
I'll never understand this.		I don't understand this yet, so I may need another explanation.
The teachers don't help me.		Teachers are my coaches, but I need to practice on my own.
Making mistakes makes me a failure.		Mistakes happen to everyone and making mistakes grows my brain.

### Question 7

Thought replacement application.

Using your responses above, write your own version of the thought replacement exercise.

What is a harmful thought for you regarding math or life in general and what is a more helpful thought you can replace it with?

\_\_\_\_\_ → \_\_\_\_\_

### Question 8

Last question! Reflection.

- What did you like or not like about this assignment?
- What seemed the most helpful or least helpful?
- What is a situation where you will use one of the techniques we practiced (labeling, thought replacement) or another technique to cope?

You did it! Now take a well-deserved break. See you in class!