Science of Learning Lab

UCI School of Education

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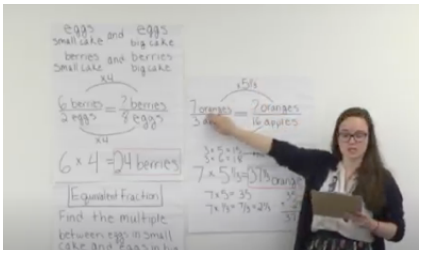

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Hello and Thank You!

Dear Teachers, Parents, and Students,

Thank you for participating and collaborating in our recent Math Study! Our goal in sending this newsletter is to ensure that our work reaches our community. We are sharing some of the findings from our recent studies and evidence-based tips that we hope will be useful in your classroom and even at home for parents!

We are researchers at the University of California, Irvine. As educational psychologists, we study how to support a child's thinking and learning. Our lab focuses mostly on math, but we also research how to improve students' deep, critical learning skills in general.

The Common Core math standards have changed the way we look at math, and how and why we should teach it to children. We want to engage and motivate students to learn mathematic principles and develop flexible math skills!

Some key tools mathematicians and researchers have found to promote this deep and flexible learning are using worked examples and multiple simultaneous strategies to solve math problems. These methods are powerful teaching tools, so we have tested these along with other practices to help support a student's learning process.

Within the last year, we have also been studying how the context of distance and hybrid schooling makes teaching and learning more challenging. In this newsletter, we suggest some tips that can help support students' learning, which teachers and parents can bring into their classroom or home conversations.

Lastly, we would love to hear your input! Please feel free to reach out to us using the contact information at the top of the page. Having open discussions with teachers, parents, and students will help inform our research on how to best promote student learning.

Thank you again for participating in our study!

Learning Under Pressure: What We Can Do to Help

As many of us have seen and felt, the pandemic has brought about drastic increases in distress for people of all ages, including young students. When we experience high levels of distress, our brains tend to focus on and attempt to fix the negative thoughts. This distraction takes up a lot of our limited cognitive resources that we need for performance on any task. For students, this heightened distress might mean that despite their desire to succeed, they may become increasingly more distracted or disengaged during learning. Mindfulness training and making sure there is a visual record of instruction for students to come back to may be effective ways to ensure students learn, even when they may be distressed and distracted.

We have studied the effects of pandemic-related distress on learning with both elementary school students as well as college students. **We found that distress reduced learning potential because the more distressed students were, the more their mind wandered during the lesson.** In other words, distressed students have a lot going on in their minds, which makes it harder for them to focus on the task in front of them.

We found similar patterns in 5th and 6th grade classrooms. We had students answer several questions about their experience during the pandemic and online learning. **Overall, students were pretty distressed about the pandemic and its consequences.** To measure the impact of this stress, students completed a math activity where they watched videos and solved division, ratio, and proportion problems. During both the lesson and test, we measured how much their mind wandered and **found that students with higher stress were more distracted,** even those who were successful at completing the activity.

To help students cope with this additional stress, we tested strategies by which teachers and parents may support their students' learning and engagement. Specifically, we examined two forms of support:

- **Emotion regulation**: Mindfulness training may reduce mind wandering, improving learning. Our research with college students showed that mindfulness training (nonjudgmentally acknowledging and letting go of distressing thoughts) can help students reduce the amount of mind wandering.
- **Visual support during math instruction**: For 5th and 6th graders, the way that the teacher in our video lesson presented material helped protect students from increased distractibility when distressed. Students who were shown worked examples (more details on worked examples in next section!) mind wandered less, particularly those who had more pandemic stress (see graph). Thus, worked examples are always helpful, but may particularly help students when they are feeling worried or distressed.

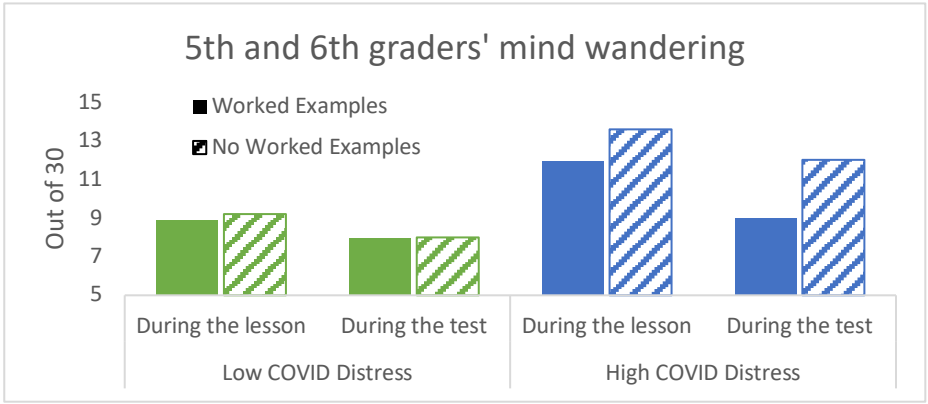


***Figure 1**: Students with less pandemic stress (green) reported less mind wandering than students with high pandemic stress (blue). For students with high pandemic stress, worked examples lowered mind wandering, as shown by the gap between the solid and striped blue bars.*

In summary, emotional distress can increase mind wandering and distractions while learning. This promising research offers some strategies that teachers can integrate into their classrooms to help support students.

Key Techniques to Support Children's Mathematical Thinking

As researchers, we are constantly exploring and testing new methods to help students grasp challenging mathematical concepts. Recently, we have studied strategies such as using worked examples and teaching more than one way to solve a problem, to test how these benefit student learning.

This is important for students – now more than ever!

When solving problems, students use their executive functioning system – the cognitive horsepower they need to hold multiple things in their mind. For example, on a word problem, children must read the story, attend to the numbers of the problem, determine the goal, choose the optimal solution strategy, and complete the calculations. Teachers get cognitive overload too, like the stress they may feel in the classroom from the challenges of trying to teach a concept, actively engage with and monitor students, and sometimes even lead students simultaneously in the classroom and on Zoom – all while dealing with their own personal stress.

Aside from everything that always goes on in the classroom and at school, this year there are even more distractions and added stress from the pandemic. This further burdens kids' executive functions, making it more difficult to learn new concepts. So, we wanted to know: what techniques help support learning, whether or not students are facing extra stress?

The Role of Worked Examples

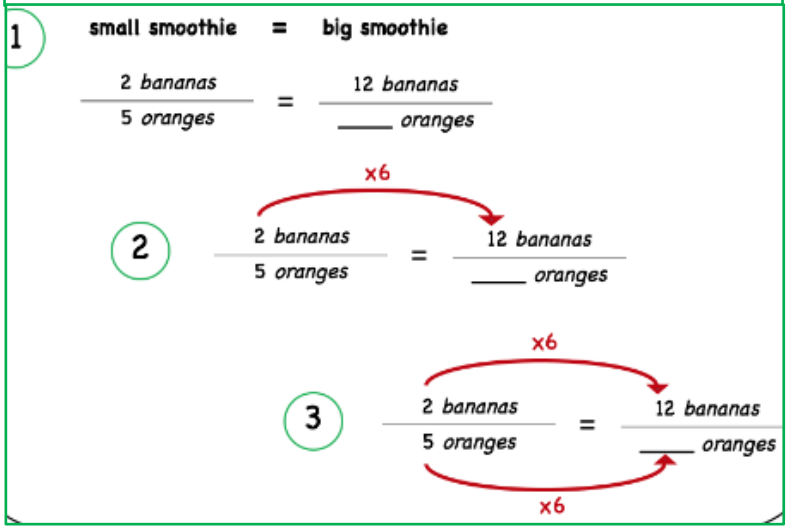
Giving students a problem with all the steps of a solution written out is called a **worked example**. This can be helpful as a reference when students try to solve new problems. In our past research, we tested whether providing these step-by-step worked examples during practice problems can reduce cognitive overload.

We wanted to know the best way to use worked examples. Is it better to provide a fully worked example *or* have students fill in the procedures of a partially worked example, like in the smoothie example below? Which would you guess is better: A, B, or C?

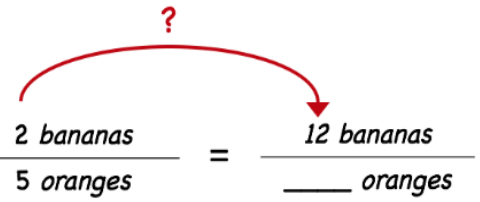
To properly support students, we need to determine how instruction impacts understanding.

Featured Example: A smoothie recipe calls for 2 bananas and 5 oranges. To make a bigger pitcher of the smoothie with 12 bananas, how many oranges should you add?

A: Fully Worked Example: Look and then find the answer



B: Partially Worked Example: Solve by filling in the missing number



C: No Example: Solve the problem

We found that using **A** (**fully worked examples)** to introduce new solution strategies led to:

1) **Overall higher test scores**
2) **More tries of the novel solution strategies**
3) **More accurate use of the new strategies**

Fully worked examples may be particularly advantageous in cognitively demanding math contexts, like solving word problems. Without support from worked examples, students were unlikely to attempt new instruction strategies and were more likely to encounter misconceptions and errors. Overall, we found that fully worked examples are a great tool to support students during instruction.

The Impact of Fully Worked Examples

We found that by using **fully worked examples** in our lesson for students, we were able to:

⇒ Reduce cognitive burden
⇒ Reduce means-end search
⇒ Increase efficiency
⇒ Improve quality of learning

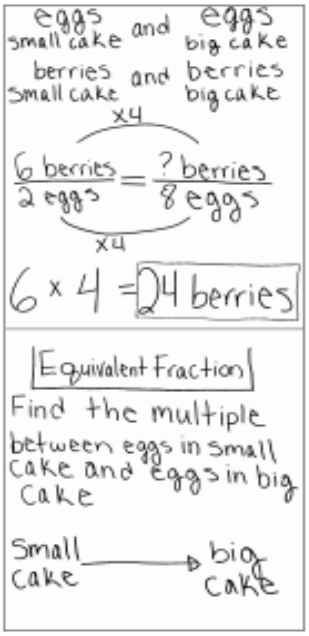
Teaching with Simultaneous Solution Strategies

Math is challenging – teaching and learning to solve math problems in multiple ways can be a powerful learning tool to promote deep and flexible learning. While teaching multiple solution strategies helps to support learning, it can be complex! In our research, we have tested what tools help kids learn **multiple problem-solving strategies simultaneously, promoting deep learning!**

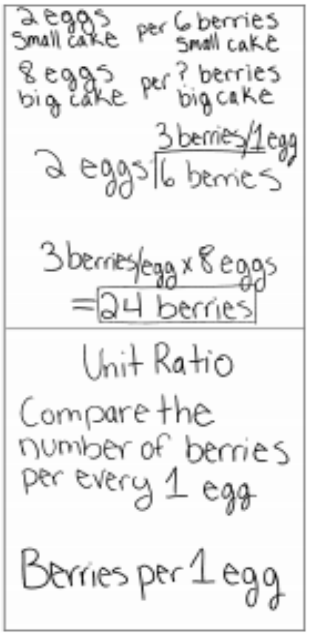
How do we implement this?

- **Have students "teach" the class.** Teachers can introduce new ideas by giving kids a problem for them to solve on their own first. Bringing students to the board and having them "teach" strategies to the class is motivating and engaging! After a student introduces a strategy, provide the class with an overview and highlight any misconceptions.
- **A great tool for comparing multiple strategies is to show the two solutions simultaneously throughout the discussion**. For example, the images on the right show the procedures (top images) and highlight the key conceptual features of solution strategies (bottom images). It's important to discuss and compare how the students reached the same answer, but in different ways. Leaving these examples up for the whole discussion, or even the rest of class, creates a record for kids to come back to if their minds get distracted.

Strategy 1



Strategy 2



- **Comparison questions can make this more effective!** Helpful prompts that teachers can use include *"Which solution is correct? Which solution is more efficient? How are these different? How are they the same? Can we use both strategies?"*

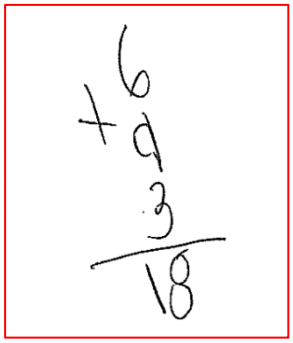
Setting up discussions as a comparison allows students to think creatively and abstractly when solving problems by **helping students draw relationships and compare between problem strategies**, which ultimately deepens their learning and understanding of a concept.

How We Determine What Students Really Know: Looking Beyond Final Answers

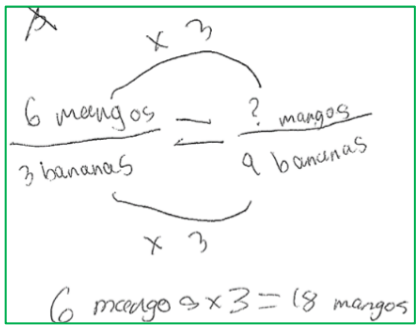
Now more than ever, teachers and parents may find their free time and energy to be at an all-time low. When reviewing students' work, sometimes it may seem wasteful to look past the accuracy of the final answer to understand the steps leading up to that answer. However, a **student's work often reveals more about their understanding** of a problem than their final answer.

To find out what students really understand, it's helpful to go beyond their final answers.

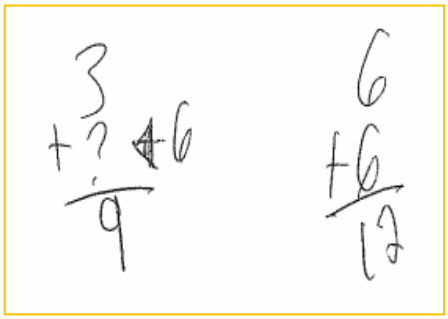
Featured Example: **A smoothie recipe calls for 3 bananas and 6 mangos. To make a bigger pitcher of the smoothie with 9 bananas, how many mangos will you need?**



Student A



Student B



Student C

Here, we can see three different students attempting to solve the same problem in our Math Study using strategies that signify different levels of understanding.

- ⇒ Although both Student A and B reached the same final answer, their steps reveal that Student B was in fact thinking proportionally and using the equivalent fraction strategy to get the correct answer. Student A, however, was not thinking proportionally but simply added the three numbers together and got lucky!
- ⇒ By looking at Student B and C we can see that both students are thinking proportionally. Student C just made a specific – and crucial – mistake in their problem solving by using addition instead of multiplication to find the relationship, resulting in an incorrect final answer. We found misconceptions like this one to be very common, so it is important to highlight these reoccurring errors students make.

Student work can show very different realities of:

1) **What students understand about a problem goal**
2) **What methods they are using to solve a problem**
3) **What details students may be missing in their problem solving**

Having this insight into what students know about a problem or strategy – and what they may still be trying to learn – **gives us direction on the best next steps for our students**. For example, you might lead one of the comparison conversations as described above, or use worked examples! When taken all together, we hope that these articles have provided you with new ideas about effective tools for reducing distraction, increasing engagement, and ultimately fostering strong mathematical thinking.

Thanks for reading our newsletter and participating in our studies!

Parents – see the next page if you are interested in participating in child studies at UC Irvine!

UCI Child Studies Collaborative

Are you a parent who is interested in contributing to child development research?

This is how you can get involved!

Researchers at UC Irvine are working together to reach out to the community about opportunities for parents to participate in various child studies at UCI.

You are invited to be included in a database indicating that you may be interested in participating in research studies at the Universityof California, Irvine with your infant, child, or adolescent, all of which include compensation. Parents with children of all ages, from 0-18 years, are welcome. Inclusion in this database is completely voluntary and you may ask to be removed at any time.

If you decide you would like to be added to the database, researchers at UCI may contact you if your child becomes eligible to participate in a study. As part of these in-person and virtual studies, children may play games, solve problems, and participate in engaging activities that will help us better understand child development. If you are contacted about an eligible study for your child, you are under no obligation to participate in that specific study.

You will not be compensated for signing up for the database, but the studies that you may be invited for will always offer compensation for your time if you decide to participate and a small prize or gift for your child.

If you are interested, you can get more information and sign up through any of the following ways!

- Check out our online form at https://tinyurl.com/ucichildstudies
- Email us at ucichildstudies@gmail.com
- Call us at (949) 415-6082

If you have any comments, concerns, or questions regarding the conduct of this research, please contact the lead researcher, Lindsey Richland, at (949) 824- 8729 or l.richland@uci.edu.