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Connecting Weirdness and Wonder to Mathematics

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Connecting Weirdness and Wonder to Mathematics

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Abstract: Middle school students are weird and wonderful. Why not bring some of that weirdness and wonder into the mathematics classroom? Effective teachers of mathematics can create a culture of engagement, curiosity, and collaboration in mathematics instruction by presenting "weird" problems (as opposed to word problems) and giving students opportunities to explore their wonderings. Inspired by "the bizarreness effect," the problems presented here are infused with humor and designed to intrigue young adolescents.

Keywords: middle school, mathematics, problem solving, the bizarreness effect, humor, engagement, productive struggle

Introduction

Middle school students are weird and wonderful. Why not bring some of that weirdness and wonder into the middle school mathematics classroom? Effective teachers of mathematics can create a culture of engagement, curiosity, and collaboration in mathematics instruction by presenting "weird" problems (not merely "word" problems) and giving students opportunities to explore their wonderings. In this article, "dare to be weird" meets "productive struggle." Our goal is to share novel problem solving activities designed to intrigue young adolescents.

The Nature of Adolescence

Adolescence is a unique time in the human lifespan. Young people ages 10-15 experience dramatic changes in physical, cognitive, social, and emotional development. Physical development refers to biological factors such as body weight and proportion, gross and fine motor skills, structural refinement in the brain, and hormonal changes. From a physical standpoint, rapid and uneven growth can lead to fatigue and restlessness in the classroom. Cognitive development refers to the ability to think, reason, and solve problems. During the middle school years, students develop increasingly complex ways of thinking and their thinking begins to shift from concrete to abstract reasoning. They also become more skilled in metacognition, or thinking about thinking. Young adolescents are now capable of understanding irony and subtle humor.

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As young adolescents are gaining physical and cognitive maturity, their social skills are burgeoning. Through peer interaction, adolescents learn about reciprocity of relationships; adolescents explore the principles of fairness and justice by working through disagreements with peers.

Emotional development refers to the ability to regulate one's own behavior and respond to others' emotions with sensitivity. Young adolescents experience some of the most profound emotional changes in the lifespan and have an intense need to belong and fit in. They need to feel loved, appreciated, cared for, and respected. According to the Association for Middle Level Education, successful middle schools respect and value young adolescents (Bishop & Harrison, 2021). Additionally, middle level educators must be specifically prepared to teach young adolescents and possess a depth of content area knowledge (Bishop & Harrison, 2021).

We understand that young adolescents are bright and curious. They respond well to structure and consistency, but they also crave novelty and the opportunity to make choices as they explore their identities. It is imperative that teachers stretch the curriculum to make explicit connections to their students' interests. A powerful way to meet the unique developmental needs of young adolescents is to offer opportunities for collaborative problem solving using unusual topics that appeal to this unique age group.

Problem Solving in Mathematics

The importance of problem-solving in learning mathematics stems from the belief that mathematics is primarily about reasoning, as opposed to repeating a set of memorized, rehearsed procedures. Students acquire their understanding of mathematics and develop problem-solving skills as a result of applying their knowledge in new situations, rather than being taught skills in isolation. Mathematics requires not only computational skills but also the ability to think and reason mathematically in order to solve new problems. Problem-solving thus allows students to transfer what they have already learned to unfamiliar situations (Kurz & Bartholomew, 2012).

In his seminal work, Pólya (1945) published a set of four principles of problem-solving to support teachers in helping their students. He argued that problem-solving is not linear but rather a complex, interactive process. Students move backward and forward between and across Pólya's phases to

1) understand and explore the problem; 2) find a strategy; 3) use the strategy to solve the problem; and 4) look back and reflect on the solution. Schoenfeld (1985, 2017) emphasizes the value in learning to think mathematically. Ahmed (1987) established that effective problems are accessible and extendable; allow individuals to make decisions; promote discussion and communication; encourage originality and invention; encourage "what if?" and "what if not?" questions; and contain an element of surprise.

The Bizarreness Effect

Would you rather have a toaster for a head or a cactus for a spine? Would you rather sound like a duck or swim like a squid? What would happen if you never cut your toenails? How would our view of space change if the moon was actually made of cheese? If you could transport one furious elephant into any point in history, where would you put it? If you died and had to choose one place to haunt for the rest of eternity, where would you choose to haunt? These are the kinds of questions that will capture the attention and interest of our middle school students.

Problems are most effective for young adolescents when they contain unusual or memorable content. Einstein, McDaniel, & Lackey (1989) describe the "bizarreness effect." They found that unusual information is generally recalled better than common information. A similar phenomenon occurs in psychology called contextual distinctiveness, which refers to the ability to better recall and remember events or items that are unusual, uncommon, and distinct. Landrum, Brakke, & McCarthy (2019) contend that if a teacher creates intrigue or an unusual outcome to a problem, students are more likely to remember the information. Waddill & McDaniel (1998) found that introducing bizarre or unusual information results in better recall because unusual content elicits different encoding processes.

Humor has also been found to enhance lecture recall (Kaplan and Pascoe, 1977). In a recent study, Van Dooren et. al (2019) conducted a study with 148 sixth graders and found humor to be an effective tool to build a bridge between mathematics and real world problem solving. These types of questions may also help relieve some math anxiety. In the *Math Curse* (2009), Scieszka and Smith ask humorous questions with a touch of relevancy from the perspective of a student who reluctantly sees everything as a math problem. For example, "The Mississippi River is about 4,000 kilometers long. An M&M is about 1 centimeter long. There are 100 centimeters in 1 meter, and 1000 meters in 1 kilometer. Estimate how many M&Ms it would take to measure the length of the Mississippi River" (p. 12).

Productive Struggle in Mathematics

"Weird questions" can prompt our students to engage in productive struggle. Productive struggle occurs when students think creatively, try different avenues towards solutions, exert effort and self-correct to attempt to solve problems (Granberg, 2016). From a neurological perspective, productive struggle leads to better learning due to the increased production of white matter in students' brains called myelin (Sriram, 2020). As myelin increases, brain signals travel faster and more efficiently.

Types of productive struggle may include confusion over getting started; carrying out a process but encountering an impasse; having difficulty explaining one's work; and misconceptions that result in errors (Zeybek, 2016). To solve a challenging problem, students must engage in self-regulated learning (SRL), which theorists define as students' ability to deliberately use cognitive and metacognitive processes to achieve a learning goal (Zimmerman & Schunk, 2011). Models of SRL generally describe how students define the task, set goals, plan and enact strategies, and evaluate progress during an academic task. Munzar, Muis, Denton, & Losenno (2021) examined what happens when this process is interrupted because of an impasse: "Whether it be a gap between prior knowledge and the conceptual demands of the problem, a lack of motivation, attentional issues, or weak domain general problem-solving skills, students will likely experience an impasse when trying to solve a challenging problem" (p. 2). Munzar, Muis, Denton, & Losenno (2021) argue that impasse-related emotions play a critical role in learning tasks; as they unfold, they provide feedback to students in terms of how well they are comprehending the content and progressing through the task. Challenging problems force students to focus on what caused the impasse, which results in deeper learning.

Parents and teachers may show concern over the idea of productive struggle, thinking if students struggle excessively or never discover the answer, then they won't reap the benefits. Studies suggest otherwise; productive failure contributes to student success on well-structured and higher-order thinking problems (Kapur, 2012). Several findings suggest that it may be "more productive to delay the addition of scaffolding until the student reaches an impasse—a form of failure—and is subsequently unable to generate an adequate way forward" (Kapur, 2012, p. 47).

The challenge for teachers is ensuring the problems are designed to support mathematics learning and are appropriate and challenging for all students. Teachers profoundly influence students' perceptions of and approaches to struggle in the mathematics classroom. According to the National Council of Teachers of Mathematics (2014), productive struggle is one of eight mathematical research-based teaching practices. In *Principles to Action*, a description of productive beliefs is shared: "An effective teacher provides students with appropriate challenge, encourages perseverance in solving problems, and supports productive struggle in learning mathematics" (n.p).

The problems need to be difficult enough to provide a challenge but not so difficult that students cannot succeed. A starting point for teachers "to encourage mathematics creativity may occur by prompting students to pay attention to their wonderings. . . [and to] capture their ideas and build on them" (Moore-Russo, Simmons, & Tulino, 2020, p. 131). In productive classrooms, students work on complex problems, are encouraged to take risks, and can struggle and fail, yet still feel good about working on difficult problems (Boaler, 2016). Teachers can foster a classroom culture that values and promotes productive struggle by 1) providing students with challenging tasks that are accessible to all students; 2) establishing the expectation that everyone will persist when solving challenging mathematical tasks; and 3) prioritizing process over product.

Offering guidance to teachers, SanGiovanni, Katt, and Dykema (2020) provide six action steps for prompting and nurturing students' productive struggle before, during, and after mathematics lessons. A key to success is in the intentionality in planning and teaching. The research is clear: Educators do not need to lead passive learners through a narrow path to success or the "correct" answer in the most efficient manner (Kapur, 2012). Facing disequilibrium or a discrepancy is desirable— even necessary— for deep learning to occur. Temporary failures "invoke mechanisms and processes that lead to more differentiated and complex conceptual structures" (Kapur, 2011, p. 562). Assistance should only be offered after the learner has had an opportunity to wrestle with the problem. Teachers should emphasize that students are not expected to be able to solve the problem, but "to generate multiple representations and methods even if these do not lead to a successful solution" (p. 575).

Generating "Weird" Questions

So how can we design "weird" questions to intrigue and inspire our middle-level mathematics students? Below is a list of questions that build upon prior studies of the "bizarreness effect," contextual distinctiveness, and humor. We argue that this approach promotes student engagement and improves the encoding and recall of academic information, specifically mathematics concepts.

Weird Questions for Mathematics

- If your bed sheets had to be made of deli meat, how would you calculate the amount of meat you would need?
- We have just received word of an impending zombie apocalypse. How many people could we save if our classroom was designated as a shelter? How could we find out?
- What is the only number that has the same number of letters?
- Would you rather have 10 mg of gold or 1 gram of silver?
- Would you rather have your money double every day for a month or have it squared every day for a week?
- How many liters of Gatorade will fill a swimming pool?
- How many pennies would fit inside a wheelbarrow?
- If you could invent a new unit of measure, what would it be?
- How many pieces of dandruff would support your body weight?
- How many acres of cotton would you need to plant to make a million dollars?
- How long would it take you to travel from Valletta to St. Paul's Bay in Malta if you were riding a camel?
- If a Skittles candy measures 1 centimeter, how many Skittles would it take to measure across the Lake Murray Dam if the dam measures 1.7 miles? How many calories would I eat if I ate the Skittles while I walked across the dam?
- In 2021, Lebron James won 4 championships and has a salary over 41 million dollars. In 1998, Michael Jordan's top salary was 33 million and he has won 6 championships. Who was the better basketball player - the GOAT?
- How does something as heavy as an airplane leave the ground and stay in the air?
- How can I use the Golden Ratio to prove that my friend's face is perfect?

Conclusion

We advocate using "weird problems" to connect mathematics content to young adolescent interests and kindle their curiosity. This strategy increases student engagement, promotes higher-order thinking, and provides opportunities for collaboration. Providing students with developmentally appropriate "weird" problems invokes inquiry and helps them actively construct their ideas about mathematics. As students explore their wonderings, they take risks, try new strategies, and give and receive feedback. They share a range of points of view and discuss different ways of solving a problem. They learn to test mathematical boundaries, explore mathematical ideas and relationships, and think creatively. Students apply, self-monitor, and adapt new mathematical knowledge to fresh situations and contexts. Moore-Russo, Simmons, & Tulino (2020) make an important distinction between exercises and problems: "Exercises are tasks for which the solution path, even if tedious and lengthy, is known, and problems are tasks for which the solution path [is] not immediately obvious" (p. 132). Teachers can use the "weird problems" approach as a best practice to empower students to explore, persist, and collaborate. The benefits are enormous as students struggle to make sense of the problem, learn to generate questions to get more information, apply mathematical reasoning, and persevere. The goal is to make math engaging, challenging, and fun.

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