Understanding and Cultivating Mathematical Resilience in Students

Jackson[1] has never really liked math. In class, when he doesn't understand a concept (which is often), he usually makes a joke, distracts a friend, or finds some other way to disengage from the discussion in the classroom. His sporadically turned-in assignments receive poor grades, and he performs poorly on assessments.

Jennifer sits a few seats over from Jackson but completes her work without complaint. She doesn't enjoy math either, seeing it as pointless, but she doesn't want to earn a bad grade. For her, math is just something she must get through to have time to do other, more interesting things.

Marcus, who finds math extremely easy, sits at the back of the class. Because he is rarely challenged, he usually gets his work done quickly and moves on. He doesn't see much use for mathematics, but he can get a solid grade easily because he's "good at it."

Part of the role of mathematics educators is to instill in students an interest in their subject, an understanding of its applicability, and confidence that they can achieve mastery of the topic. As educators, we must instill a mathematical resilience that will support students in future mathematics courses[2] and future careers—indeed, their entire lives.

Each of the three students in the paragraph above displays behavior indicative of low mathematical resilience. Some students show their lack of resilience in overt ways, as in the case of Jackson, who acts out when facing a concept he believes he cannot master. Other students' lack of resilience is more covert than Jennifer, who doesn't display any poor behavior but regards math as "pointless." Some students do not display their lack of resilience until they enroll in future courses when concepts may not come so easily, like Marcus.[3]

Borman and Overman[4] define resilience as a developmental process that leads to increased academic performance despite the adversity working against it. Many authors have offered similar definitions for resilience and shared ideas on how to overcome it.

Several concepts are important to consider when developing mathematical resilience in students. First, it is essential to recognize that resilience is not something a person either has or does not have. It can be either fostered or hindered based on interpersonal relationships and social support.[5] As teachers, we bear the greatest responsibility for developing academic resilience in our students, as we are the direct interpersonal contact they have in our classrooms. Other educational personnel, adults in students' lives, and peers also play a significant role.[6]

Second, we differentiate between a fixed mindset and a growth mindset. A fixed mindset holds that each person has an unchangeable capacity to learn. This view is often pervasive with regard to mathematics and recognizable and disparaging statements such as "I'm not a math person" or "I'm never going to get this." A mathematically resilient student displays a growth mindset and believes that his or her current lack of understanding has the potential to change and that this change can occur as the result of working to acquire greater expertise.[7]

Third, resilience develops in the

ANTHONY BOSMAN and ADAM HECK

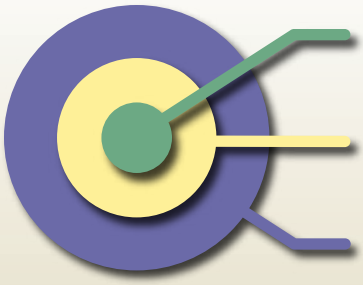
presence of adversity. A course that does not significantly challenge students and expose them to problems they do not immediately know how to solve will not produce the "stick-to-itiveness" needed for higher-level problem-solving.

Goodall and Johnston-Wilder[8] have identified three zones (based on Vygotsky's Zone of Proximal Development) that are helpful here. The innermost zone, called the "comfort zone," is the safe zone where a student isn't challenged and feels comfortable navigating the material with little help from others. The outermost zone, classified as the "danger zone," is characterized by extreme difficulty and high stress for the learner. It can often lead to a fight, flight, or freeze response. Neither of these zones leads to the development of resilience—or much learning, for that matter. It is in the space between these two zones, called the "growth zone" by Goodall and Johnston-Wilder,[9] where learning happens, and resilience develops. The growth zone provides sufficient academic challenge and an environment that allows for safe exploration of a topic as well as the freedom to ask questions. [See Zones of Proximal Development chart].

Resilience rarely develops in hostile environments. A student who feels threatened, judged, inadequate, or disliked by the teacher will have little desire to put in the work needed to develop mathematical resilience. However, students who attend a school marked by a safe and orderly environment and who have a positive relationship with their teachers tend to develop higher levels of resilience.[10]

In the following paragraphs, we offer ideas for activities and practices that may produce academic resilience in students. As you read these, keep in mind that more important than any activity or practice is the development of a safe, caring, and orderly environment where a student can learn. No activity or practice can ever replace a teacher who makes a student feel loved and valued.

Zones of Proximal Development



Zone 1 - Comfort Zone
Students feel comfortable in their ability to learn without help.

Zone 2 - Growth Zone
Students feel safe exploring new material, asking questions, and accepting help from others.

Zone 3 - Danger Zone
Students find it difficult to learn without help and experience high stress.

1. *Mathematical Resilience Scale*. The Mathematical Resilience Scale is a research-validated survey to assess student attitudes that contribute to mathematical resilience.[11] It has students indicate their level of agreement with statements about their perception of the value of mathematics, the necessity of struggle in learning mathematics, and the possibility of growth in mathematical ability. Value statements include "Math courses are very useful no matter what I decide to study" and "Mathematical thinking can help me with things that matter to me." Struggle statements include "Everyone struggles with math at some point" and "Making mistakes is necessary to get good at math." Growth statements include "Anyone can learn math" and "Everyone can get better at math." Educators can use such tools to help gauge students' attitudes toward their classes and the effectiveness of various interventions.

2. *Low-floor, High-ceiling Tasks*. A low-floor, high-ceiling task is an activity designed to be accessible to all students (low-floor) while also extending to high levels (high-ceiling). The activity allows students to work at different paces and boosts their confidence as they make meaningful contributions to the problem and deepen their conceptual understanding.[12] For example, one might present students with a 4 x 4 grid and ask them to count the number of ways to travel from the bottom left to the upper right. All students can engage this problem by thinking about a systematic way to count the paths and looking for patterns. The problem also invites generalization to challenge students in appropriate ways: consider a 5 x 5, 6 x 6, or more generally, an n x n grid, or even a rectangular m x n grid. Note that low-floor, high-ceiling tasks are designed so that "everyone can get started and everyone can get stuck."[13] Thus, all students have an opportunity to experience mathematical struggle and develop mathematical resilience. Several tasks for various grade levels are available at youcubed® (see https://www.youcubed.org/).[14]

3. *Growth-focused Grading*. Educators can help students develop growth mindsets that promote resilience.[15] For instance, mastery-based grading shifts the attention from earning points to mastering the course objectives by the end of the term, giving students multiple opportunities to demonstrate mastery. This principle can be introduced into a course with a traditional grading system by allowing students to reattempt missed problems on assignments or exams for partial credit or through digital-learning platforms that give students instant feedback and allow multiple attempts. Similarly, second-chance grading allows students to retake alternative versions of quizzes/exams throughout the semester to demonstrate mastery.[16]

Teachers should encourage a growth mindset when discussing grades with students. Low performance on math assessments is often related to mathematical anxiety and can lead to avoidance.[17] Educators can intervene by reminding students that there will be additional opportunities to demonstrate their mastery, encouraging them to focus on learning from their mistakes rather than interpreting them as a sign of their lack

of ability. One author of this article (A.H.) has made *successful failure* a small portion of his overall course grade (5 percent). Students earn these points at the end of the semester by writing about a time they faced a setback or disappointing failure in the course and telling how they overcame and grew from it. Knowing that completing this assignment is necessary to earn full points for the course helps students anticipate setbacks and appreciate the essential role of resilience in learning.

4. *Character Statement*. One of the authors of this article (A.B.) has his students recite together and sign the following character statement before every exam:

- I will persevere on this exam, giving my best effort.
- I will exercise integrity, not giving or receiving any unauthorized aid on this exam.
- I will learn from my mistakes, reviewing the graded exam when it is returned to me.
- I will trust that I am worth infinitely more than any exam score, for I have been redeemed at infinite cost (1 Corinthians 6:20).

The character statement reminds students, at a high-stakes time, of their commitment to integrity,[18] persistence, and growth—but above all, their inherent value. Educators can craft their own statements, borrowing or adopting the above language, or develop a statement with their class as part of a lesson on mathematical resilience at the beginning of the term. This statement might then be included on significant assignments and displayed on a classroom poster. ✐

This article has been peer reviewed.

Anthony Bosman, PhD, *is an Assistant Professor of Mathematics at Andrews University (Berrien Springs, Michigan, U.S.A.). He earned his bachelor's degree from Stanford University (Stanford, California, U.S.A.) and a doctorate in mathematics from Rice University (Houston, Texas, U.S.A.). Dr. Bosman's area of research is low-dimensional topology, the study of shapes and surfaces up to continuous deformation. His research focuses on knots and links. He has taught several undergraduate mathematics courses, enjoys working with math-enrichment programs to get secondary school students passionate about mathematics, and serves as a leader in campus ministry.*

Adam Heck, MS, *is an Associate Professor of Mathematics at Southern Adventist University (Collegedale, Tennessee, U.S.A.). He earned a bachelor's degree in mathematics from Andrews University (Berrien Springs, Michigan, U.S.A.) and a Master's degree in mathematics at the University of Central Florida (Orlando, Florida, U.S.A.). Before teaching at Southern Adventist University, Mr. Heck taught at Atlanta Adventist Academy (Atlanta, Georgia, U.S.A.); Forest Lake Academy (Apopka, Florida, U.S.A.); and Florida Hospital College of Health Sciences (Orlando, Florida U.S.A.).*

Recommended citation:
Anthony Bosman and Adam Heck, "Understanding and Cultivating Mathematical Resilience in Students," *The Journal of Adventist Education* 84:1 (2022): 4-6.

NOTES AND REFERENCES

1. All names used in this article are pseudonyms.

2. Sue Johnston-Wilder and Clare Lee, "Mathematical Resilience," *Mathematics Teaching* 218 (2010): 38-41.

3. Elena Nardi and Susan Steward, "Is Mathematics T.I.R.E.D.? A Profile of Quiet Disaffection in the Secondary Mathematics Classroom," *British Educational Research Journal* 29:3 (2003): 345-367.

4. Geoffry D. Borman and Laura T. Overman, "Academic Resilience in Mathematics Among Poor and Minority Students," *The Elementary School Journal* 104:3 (2004): 177-195.

5. Sadguna Anasuri, "Building Resilience During Life Stages: Current Status and Strategies," *International Journal of Humanities and Social Science* 6:3 (2016): 1-9.

6. V. Bailey Gillespie, Gary L. Hopkins, and Stuart Tyner, "Making Students Bulletproof—Resiliency, the Paradigm of Hope," *The Journal of Adventist Education* 61:2 (December 1998/January 1999): 10-14. Although an older source, the authors of this article conducted groundbreaking research on this topic. They state, "One factor emerges repeatedly in research and literature about resiliency, both in the U.S. and other countries: A sincere and enduring relationship with a caring and charismatic adult—someone with whom they identify and from whom they gather strength—is the *most* significant factor in the lives of youth and young adults" (p. 12).

7. Carol Dweck, *Self-theories: Their Role in Motivation, Personality, and Development* (Philadelphia, Penna.: Psychology Press, 2000).

8. Janet Goodall and Sue Johnston-Wilder, "Overcoming Mathematical Helplessness and Developing Mathematical Resilience in Parents: An Illustrative Case Study," *Creative Education* 6:5 (2015): 526-535.

9. Ibid.

10. Borman and Overman, "Academic Resilience in Mathematics Among Poor and Minority Students."

11. Janice Kooken et al., "Development and Validation of the Mathematical Resilience Scale," *Measurement and Evaluation in Counseling and Development* 49:3 (2016): 217-242.

12. Bina Kachwalla, "Making Math Accessible to All Students: Effective Pedagogy?" *Journal of Higher Education Theory and Practice* 21:3 (2021). https://articlegateway.com/index.php/JHETP/article/view/4145.

13. Lynne McClure, "Using Low Threshold High Ceiling Tasks in Ordinary Classrooms" (2011): https://nrich.maths.org/content/id/7701/LTHCArticle.pdf.

14. Betina A. Zolkower and Laurie H. Rubel, "Not 'Just Another Brick in the Wall,'" *Mathematics Teaching in the Middle School* 21:2 (2015): 84-89.

15. David Scott Yeager and Carol S. Dweck, "Mindsets That Promote Resilience: When Students Believe That Personal Characteristics Can Be Developed," *Educational Psychologist* 47:4 (2012): 302–314.

16. Oscar E. Fernandez, "Second Chance Grading: An Equitable, Meaningful, and Easy-to-Implement Grading System That Synergizes the Research on Testing for Learning, Mastery Grading, and Growth Mindsets," *PRIMUS* 31:8 (2021): 855-868.

17. Ray Hembree, "The Nature, Effects, and Relief of Mathematics Anxiety," *Journal for Research in Mathematics Education* 21:1 (1990): 33–46.

18. Holly Tatum and Beth M. Schwartz, "Honor Codes: Evidence Based Strategies for Improving Academic Integrity," *Theory Into Practice* 56:2 (2017): 129-135.