Can Everyone Master Mathematics?

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Twenty secondary math and science teachers from a large urban school district in Texas were recently asked: Why don't English language learners succeed in school? Their answers included: students feel isolated because of language, students get mixed up with gangs, and students do not value education.

The teachers then divided their answers into two groups: those that place the responsibility for succeeding in school on the student, and those that place the responsibility on the school itself. All 27 of the reasons given placed the responsibility on the students rather than on the adults charged with educating them.

In further conversations, the teachers agreed that there is a significant number of institutional barriers to learning for students. This article compares *student-attributed* and *school-attributed* explanations for the persistent failure of many students to develop mathematical thinking and offers alternatives for success.

One key question is: Why do inherently bright students (including native-born, recent immigrant and English language learners, etc.) continue to lose interest and give up on mathematics?

Typical student-attributed explanations include: these students cannot persist in sustained abstraction; these students are disengaged from the subject; these students do not understand the language of math; and these students do not get help or encouragement at home.

These kinds of explanations minimize the power that teachers have. But educators can directly affect how they perceive students as mathematical thinkers. Teachers can carry out the curriculum creatively with expanded methodology and engage all students in higher-order-thinking conversations. Successful teachers acknowledge student contributions and explore connections. They check for understanding and draw on students' natural mathematics to connect it with formal math. And they connect mathematics to students' reality.

Instead, the predominant practices involve rote learning of patterns rather than seeking reasons and explanations; requiring students to "just follow along" with procedures that seem arbitrary and do not engage their critical thinking; ignoring student attempts to make connections across ideas; and prescribing to the theory of "no pain, no math gain."

We have failed the majority of our students for many generations, thereby preventing most of them from deepening as mathematical thinkers and reaping the rewards that follow. But, it does not have to stay this way.

There are small but growing groups of math teachers whose practices vary from those listed above. Their successful classroom experiences reflect the following (Dieckmann, 2003).

- Students' natural curiosity is a powerful hook for experimentation and discovery.
- Establishing mathematics as fundamentally relevant reduces students' perception of

math as arbitrary and, ultimately, unknowable.
- Students create and explain various chains of mathematical reasoning.
- Interactive and dynamic lessons entail the serious consideration of all student responses and explanations.
- Students find learning rewarding and energizing and are self-motivated to continue exploring.

Additionally, English language learners deepen as mathematical thinkers when:

- Content, language and metacognition are integral to instruction (Echevarría, Short and Voght, 2003).
- Clearly understood visuals and universal shapes are used to explore concepts, irrespective of language ability.
- Group conversations exploring math concepts develop both Basic Informal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Cummins, 1986).

Students have resources and experiences that are useful in learning mathematics. We start with the premise that all children are natural mathematical thinkers, from infancy. Various researchers support this phenomenon in mathematics education and psychology (Lakoff and Nuñez, 2001; Harel and Confrey, 1994).

Children notice shapes and patterns through play and daily activities. In playing basketball, for instance, they learn that the farther away they are from the basket, the more force they will have to use to make the shot. They have an intuitive understanding of the relationship among distance, force, and jumping height, as they relate to the likelihood of shooting the ball into the basket.

This and other common activities embody a core concept in mathematics: functions. Here is a short list of other instances where the functions concept shows up in children's everyday lives:

- The darker it gets outside (x), the closer it is to bedtime (y).
- The hungrier I am (x), the bigger serving of food I want (y).
- The more I like a certain food (x), the more I want of it (y). The converse is also true. (Think vegetables!)
- The quicker I finish my chores or homework (x), the sooner I can go play outside or watch TV (y).
- The more mud I track in on the kitchen floor (x), the more upset my mother may be (y).
- The volume of my voice (x) needs to change depending on how far away (y) I am from someone.
- If I wake up late for school (time), I must walk at a quicker pace (rate) to get to school (distance) before the bell rings.
- Even though a beach ball is bigger than a basketball (in circumference), the basketball is heavier (weight) and it takes more strength to catch it than the beach ball.
- The bigger the box (x), the better (y) the gift. (Better predictive variables soon get discovered such as shape, weight, and the kind of noise made when shaken.)

Math teachers can connect these functional relationships to school mathematics. Eventually, teachers can focus words, manipulatives, pictures, tables, and graphs to equations. Mining such mathematics experiences, teachers help students see how mathematical ideas from arithmetic, algebra, geometry and probability permeate daily living.

The math classroom becomes an exciting laboratory where experiences are studied more closely and where students learn more formalized math language and symbolic systems used to communicate their ideas.

If we hope to develop students as mathematical thinkers, we must abandon the prevailing deficit view that many students cannot master math. Schools can rethink how math is learned and taught to the benefit of all students. In doing so, teachers can be renewed in the professional satisfaction that comes from succeeding with all students.

The question for schools changes from “Why do *they* not learn math?” to “How do *we* teach math?” This leads us to re-tune our school radar to capitalize on the treasure of experiences that students bring to make the curriculum come alive. By doing so, schools can make good on their promise to educate all children.

Cummins, J. “Empowering Minority Students: A Framework for Intervention,” *Harvard Educational Review* (Cambridge, Mass.: Harvard University, 1986).

Dieckmann, J. “Learning Angles with English Language Learners,” *IDRA Newsletter* (San Antonio, Texas: Intercultural Development Research Association, March 2003).

Echevarría, J., and D. Short, M. Voght. *Making Content Comprehensible for English Language Learners: The SIOP Model* (New York, N.Y.: Allyn and Bacon, 2003).

Harel, G., and J. Confrey, editors. *Development of Multiplicative Reasoning in the Learning of Mathematics* (Albany, N.Y.: State University of New York Press, 1994).

Lakoff, G., and R. Nuñez. *Where Mathematics Come From: How the Embodied Mind Brings Mathematics into Being* (New York, N.Y.: Basic Books, 2001).

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Books
Natural Learning and Mathematics
by Joy Edmunds and Rex Stoessiger (Portsmouth, N.H.: Reed Elsevier, Inc., 1995)

Making Sense: Teaching and Learning Mathematics with Understanding
by James Hiebert, Elizabeth Fennema, and Thomas P. Carpenter
(Portsmouth, N.H.: Heinemann, 1997)

Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States
by Liping Ma (Mahwah, N.J.: Lawrence Erlbaum Associates, 1999)

Web Sites
AIMS Education Foundation
http://www.aimsedu.org/

Articles on Family Math
http://www.math.com/parents/family.html

FigureThis!
http://www.figurethis.org/

Lawrence Hall of Science - Teacher Resources
http://www.lawrencehallofscience.org/Publications/