

for both high-achieving students, who are currently turning away from mathematics in record numbers, as well as the low-achieving students who are being denied access to ideas that they are fully capable of learning. Many people agree that students need positive mindset beliefs, but if we really want to give these ideas to students, we need to fundamentally change the way mathematics is presented and taught in U.S. society. I end all of my emails to our subscribers to Youcubed with the words “Viva la Revolution!” I do this because it is clear to me that we are in need of a revolution, one that involves changing beliefs about mathematics, the subject, as well as student potential and mindset; one that involves rejecting the elitism that pervades the subject; one that involves moving from performance to learning; and one that involves embracing mathematics as a multidimensional, beautiful subject available to all.

Equitable Strategies

How then do we make math education more equitable? In the next chapters I will talk more about strategies benefitting all students, but here are some strategies for purposefully making math more inclusive.

1. Offer all students high-level content

In the next chapter I will delve into the research and suggested strategies for increasing the numbers of students who are given the opportunity to learn high-level mathematics content. International comparisons have shown that the United States offers fewer students high-level mathematics than do most other countries (McKnight et al., 1987; Schmidt, McKnight, & Raizen, 1997). A clear way of improving achievement and promoting equity is to broaden the number of students who are given high-level opportunities. I devote the next chapter to explaining the best ways to offer high-level mathematics to as many students as possible.

2. Work to change ideas about who can achieve in mathematics

Dweck’s studies, as I reviewed earlier in this chapter, show us that the mindset beliefs held by teachers open or close pathways for students, and that fixed mindset thinking and teaching is a large part of the reason inequities continue in mathematics and science, for women and students of color. The studies also show, encouragingly, that students who have a growth mindset are able to shrug off stereotyped messages and continue to succeed; this speaks again to the huge need for students, and teachers, to develop growth mindset beliefs about their own subjects and transmit growth mindset messages to students. Such messages should be given to students as early and as often as possible, and Chapters One, Two, and Nine review ways to give these messages. It turns out that growth mindset beliefs about learning mathematics may be critical in the pursuit of a more equal society.

3. Encourage students to think deeply about mathematics

In 2014 I was asked to present to the Commission on Women and Girls at the White House. The day was organized around ways to encourage more women to take STEM subjects. I told the gathered group that much of the reason we do not have equal numbers of women and men in STEM is mathematics.

I have found, through my own research (Boaler, 2002b) and other studies that have confirmed the same finding (Zohar & Sela, 2003), that girls, more than boys, desire a depth of understanding that is often unavailable in mathematics classrooms. This is not to say that all girls want something and all boys want something different, but there is a greater tendency among girls to want to understand deeply—to know why methods work, where they come from, and how they connect to broader conceptual domains (Boaler, 2002b). This is a very worthwhile goal and what we want from all of our students. Unfortunately, the procedural nature of mathematics teaching in many classes means that deep understanding is often not available, and when girls cannot gain deep understanding they underachieve, turn away from mathematics, and often develop anxiety. Girls have much higher levels of anxiety about mathematics than boys do (Organisation for Economic Co-operation and Development [OECD], 2015), and the unavailability of deep understanding is one main reason for this (Boaler, 2014a). This is ironic, because the desire to think deeply and really understand concepts is admirable, and the students who express this need are most suited to high-level work in mathematics, science, and engineering. They are the same students who could advance STEM disciplines and break cycles of inequitable teaching. When mathematics is taught procedurally, students who want depth of understanding, most of whom are girls, are denied access to STEM.

In a meta-analysis of 123 informal STEM programs for girls, including summer and after school clubs, researchers summarized the features that girls rated as creating engagement and positive identity formation. The top four features chosen by girls were:

- Hands-on experiences
- Project-based curriculum
- Curriculum with real-life applications
- Opportunities to work together

Role models were also cited, but girls believed them to be less important than opportunities for collaborative, inquiry-based work (GSUSA, 2008). This large-scale study aligns with the research that highlights girls’ preferences for a connected approach to mathematics, in which they can pursue questions of why, when, and how methods work. Girls are not alone in preferring this approach, which is also linked to higher levels of achievement, but it seems that girls need this approach more than boys, because without it they are likely to turn away from the discipline.

Learning is not just about accumulating knowledge; it is a process of identity development, as students decide who they are and want to be (Wenger, 1998). For many girls—and boys—the

identities they see offered in mathematics and science classrooms are incompatible with the identities they want for themselves (Boaler & Greeno, 2000). Many students see themselves as thinkers and communicators and people who can make a difference in the world (Jones, Howe, & Rua, 2000); in procedural classrooms they often come to the conclusion that they just do not fit in. This relates to the forms of knowledge that are privileged in many mathematics and science classrooms that leave no room for inquiry, connections, or depth of understanding.

When mathematics is taught as a connected, inquiry-based subject, inequities disappear and achievement is increased overall. Chapter Four gave many ideas for teaching mathematics in this way, and Chapter Nine gives many more examples of mathematics tasks, methods, and strategies that enable open, equitable mathematics to be offered to students.

4. Teach students to work together

Many research studies have shown the advantages of students working together for mathematics understanding (Boaler & Staples, 2005; Cohen & Lotan, 2014), and group work is a strategy

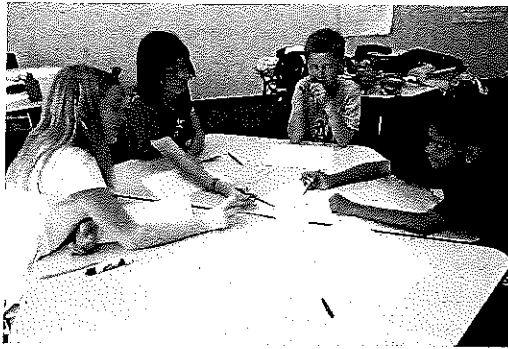


FIGURE 6.2 Students work together in a group

I regard as critical to good mathematics work (see Figure 6.2). But a fascinating study showed that group work may also be critical in countering racial inequities in mathematics achievement and course taking.

Uri Treisman is a mathematician who worked for many years at the University of California, Berkeley, and is now at the University of Texas. When he was at Berkeley, Treisman was alarmed to find that 60% of African American students were failing calculus, which for many of them meant dropping out of the university. He contrasted the African American students' experiences with that of the Chinese American students, who

had much higher rates of success. Treisman studied the reasons for the success differential among the different ethnic groups and found that many of the theories given by professors were not correct—the African American students did not, as some professors thought, have weaker preparation or lower incoming GPAs or come from poorer backgrounds. There was one clear difference between the two cultural groups: The Chinese American students worked on math together. They got together in the evenings after math class, and they worked through problem sets together. When the Chinese American students found mathematics difficult, they were supported—first by knowing that everyone was struggling and then by working together to solve problems. By contrast, the African American students worked on math alone, as a solitary experience, and when they struggled they decided they could not do math. Treisman moved from these results to instigating a new approach at Berkeley in which students were offered collaborative workshops in which they worked through mathematics together and received positive messages about their potential. The impact was dramatic, with failure rates dropping to zero within two years and the

African American students outperforming the Chinese American students who did not attend the seminars (Treisman, 1992).

This is not a solitary finding. Research tells us that when students work on mathematics collaboratively, which also gives them opportunities to see and understand mathematics connections, equitable outcomes result (Boaler & Staples, 2005).

5. Give girls and students of color additional encouragement to learn math and science

Many elementary teachers feel anxious about mathematics, usually because they themselves have been given fixed and stereotyped messages about the subject and their potential. When I taught in my online teacher class that mathematics is a multidimensional subject that everyone can learn, many of the elementary teachers who took it described it as life-changing and approached mathematics differently afterward. Around 85% of elementary teachers in the United States are women, and Beilock, Gunderson, Ramirez, and Levine (2009) found something very interesting and important. The researchers found that the levels of anxiety held by women elementary teachers predicted the achievement of the girls in their classes, but not the boys (Beilock et al., 2009). Girls look up to their female teachers and identify with them at the same time as teachers are often and sadly conveying the idea that math is hard for them or they are just not a “math person.” Many teachers try to be comforting and sympathetic about math, telling girls not to worry, that they can do well in other subjects. We now know such messages are extremely damaging. Researchers found that when mothers told their daughters “I was no good at math in school” their daughter’s achievement *immediately* went down (Eccles & Jacobs, 1986). Teachers need to replace sympathetic messages such as “Don’t worry, math isn’t your thing” with positive messages such as “You can do this, I believe in you, math is all about effort and hard work.”

In addition to equitable teaching strategies, such as collaboration and inquiry-based approaches, both girls and students of color—particularly underrepresented minorities—need thoughtful and positive messages to be given to them, about their valued place in mathematics. They need this more than other students because of the prevailing stereotyped societal messages about math. The body of work on “stereotype threat,” led by the work of Claude Steele, shows clearly the damage caused by stereotypical ideas. Steele and colleagues showed that when girls were given a message that a math test resulted in gender differences, the girls underperformed, whereas girls who did not receive that message performed at the same level as boys on the same test. Steele and colleagues went on to show that a message about gender underachievement did not even have to be given. Subsequent experiments showed that women underachieved when they simply marked their gender in a box before taking the test, compared to those who did not have to do that. He showed, through this and many other studies, that stereotypes are always “in the air” and they reduce opportunities significantly. In subsequent experiments he showed the same impact for white men when playing golf with African American men, as the white men believed they were not as “naturally” good at sports. When they were made aware of race differences before golfing, they performed at lower levels. The work of Steele and colleagues has shown that any group can suffer from stereotype threat when working in an area where another group is believed to be higher achieving (Steele, 2011).

Unfortunately, in math classrooms widespread beliefs about the naturally high achievements of men and White or Asian students are very much “in the air.” This makes it critical to address these stereotypical ideas, and one way to do this is by highlighting the achievements of women and underrepresented minorities in mathematics and STEM. In the box I give an example case that could be used in class discussions. There are many more. An ideal way to structure such a class discussion is to ask students to become an expert on the example being discussed, through the jigsaw method that I describe more fully in Chapter Eight, and then share their findings with other students.



Nala Scott, left, 11th grader, and senior Dania Allgood, members of Western High School's all-female robotics team the RoboDoves, with their latest robot, “Joan of Arcs”

Source: *Baltimore Sun*, used by permission.

A Baltimore all-female, all-African American robotics team has a shelf filled with awards for the remote-controlled robots they have conceived and built.

The RoboDoves team has been so successful they were featured in *Scientific American*. They battle against other high school robotics teams, and the girls show a competitive spirit combined with a love of mathematics, STEM, creativity, and design that could inspire many others. Various news article on this robotics team can be a source of information for students to explore (see Lee, 2014; Zaleski, 2014).

Role models are extremely important to students—and one of the reasons it is so important to diversify the teaching force.

As well as highlighting role models, take other opportunities to encourage students who may need additional encouragement. In my second year of teaching math in a London comprehensive school, I started to celebrate International Women's Day in the school by holding all-girl math sessions in which we worked on interesting math together and celebrated famous female mathematicians. I taught, at the time, at Haverstock School, an inner London secondary school with considerable cultural diversity and over 40 languages spoken by students. One noteworthy outcome of this day of celebration was that it seemed to cause many of the quieter girls, especially those from an Indian background, to gain confidence and participate more in math. Their increased public engagement continued into my math classes afterward.

There are other ways to encourage girls and underrepresented minorities in math. My main point is that it may not be enough, as a math teacher, to treat students equally in the pursuit of equity. Some students face additional barriers and disadvantages, and we must work to address those quite deliberately if we are to achieve a more equitable society.

6. Eliminate (or at least change the nature of) homework

PISA, the international assessment group, with a data set of 13 million students, recently made a major announcement. After studying the relationships among homework, achievement, and equity, they announced that homework perpetuates inequities in education (Program for International Student Assessment [PISA], 2015). Additionally, they questioned whether homework has any academic value at all, as it did not seem to raise achievement for students. This is not an isolated finding; academic research has consistently found homework to either negatively affect or not affect achievement. Baker and LeTendre (2005), for example, compared standardized math scores across different countries and found no positive link between frequency of math homework and students' math achievement. Mikki (2006) found that countries that gave more math homework had lower overall test scores than those that gave less math homework (Mikki, 2006). Kitsantas, Cheema, and Ware (2011) examined 5,000 15- and 16-year-olds across different income levels and ethnic backgrounds and also found that the more time students spent on math homework, the lower their math achievement across all ethnic groups.

It is easy to see why homework increases inequity: students from less-privileged homes rarely have a quiet place to study; they often have to do homework at night, either in the home, while their parents are at work, or at their paid jobs; and they are less likely to have resources such as books and Internet-enabled devices at home. When we assign homework to students, we provide barriers to the students who most need our support. This fact, alone, makes homework indefensible to me.

As a parent who sees her daughters stressed by homework for many nights of the week, with no time for play or the family, I have a personal issue with homework that I want to be very open about. When my eight-year-old daughter said to me last week, “I don't want to do it, I want to sit with you and play,” in the two-hour window that is our evening, I did not know what I could say, other than, “Let me write a letter to your teacher and say you are not doing the

homework tonight.” How reasonable is an eight-year-old’s request to spend her evening engaging with her family? My children are in a family of two hard-working parents; we do not even see them until 5:30 at night, when we need to prepare food for them. By the time dinner is finished and we sit down, we have one or two hours before bedtime; this time is rarely spent talking or playing, as homework pressure comes crashing down each night. This is not a good time for my daughters to be encountering difficult problems; often they are simply too tired, so they end up thinking these problems are too hard for them. It is unfair and unwise to give students difficult problems to do when they are tired, sometimes even exhausted, at the end of the day. I wonder if teachers who set homework think that children have afternoon hours to complete it, with a doting parent who does not work on hand. If they do not think this, then I do not understand why they feel they can dictate how children should spend family time in the evenings.

In addition to the inequities created by homework, the stress it causes (Conner, Pope, & Galloway, 2009; Galloway & Pope, 2007), the loss of family time, and the null or negative impact on achievement (PISA, 2015), the quality of math homework is often low, at best. In all of the years in which my eldest daughter was in elementary school, I rarely saw any homework that helped her understanding of mathematics, but I saw a lot of homework that caused her considerable stress. For some reason mathematics teachers—and their textbooks—seem to save the most procedural and uninspiring mathematics for homework. She has been given times tables to memorize; pages of 40 problems to do, all repeating one idea, and lots of questions that she learned to answer correctly in class time and did not need to repeat at home. The value of most math homework across the United States is low, and the harm is significant.

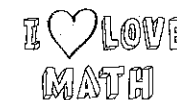
When class starts with a review of homework, inequities are magnified, with some students starting each day behind the other students. When I first moved to the United States, I was shocked to see math classes review homework for 20 to 30 minutes of each lesson. This never happens in England, where homework is treated very differently. In the middle and high schools I know in the United States, every subject gives homework every school night. In England, teachers of different subjects give homework once each week. When I was growing up, I would typically have homework from one subject each night, which took around an hour in the last years of high school. In the United States, at least in my local school district, students in high school regularly stay up until 2 a.m. finishing homework. The levels of stress reported among students are sky high, and one of the main factors causing stress is homework. The significantly smaller amount of homework assigned in the United Kingdom is probably a major reason why homework there gets far less attention and causes far less stress compared with the United States.

If as a teacher or school leader you want to promote equity and take the brave step of eradicating homework, there are many resources that share the research evidence to help you, including Alfie Kohn’s *The Case Against Homework*, Sal Khan’s arguments in *The One World School House*, and many resources from Challenge Success (for example, Challenge Success, 2012).

If you need to retain homework, then I recommend changing the nature of homework: instead of giving questions students need to answer in a performance orientation, give reflection questions that encourage students to think back on the mathematics of the lesson and focus on the

My Homework My Reflections

What was the main idea you learned today?



What is something you are struggling with or have questions about?

How could the ideas from today’s lesson be used in life?

Exhibit 6.1

big ideas, which we know to be an important orientation for their achievement (PISA, 2012). Exhibits 6.1 and 4.2 both give examples of reflection homework questions.

Alternatively, homework could be an opportunity for giving students inquiry projects; for example, to look for Fibonacci examples in the home and outside. Homework should be given only if the homework task is worthwhile and draws upon the opportunity for reflection or active investigation around the home. If homework was used in this way, and we removed the pages of mindless practice that are sent home daily, we would enable millions of students to use their time more productively, reduce stress, and take a giant step in promoting more equitable schools.