Is Math a Gift?

Beliefs That Put Females at Risk

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Why aren't more of our brightest females pursuing careers in math and science? I was catapulted into this issue by a strange finding. In our research, we were looking at how students cope with confusion when they're learning brand new material. Confusion is a common occurrence in math and science, where, unlike most verbal areas, new material often involves completely new skills, concepts, or conceptual systems. So we created a new task for students to learn, and for half of the students we placed some confusing material near the beginning (Licht & Dweck, 1984).

What we found was that bright girls didn't cope at all well with this confusion. In fact, the higher the girl's IQ, the *worse* she did. Many high IQ girls were unable to learn the material after experiencing confusion. This didn't happen to boys. For them, the higher their IQ, the better they learned. The confusion only energized them.

These findings were all the more striking because we were working with fifth-grade students. Girls were still earning higher grades than boys in just about every subject. There was no stigma attached to girls' achievement yet. And the material and problems we gave them did not involve math—so the stereotype about females and math was not in play.

Since our high IQ girls had done wonderfully well when they didn't bump up against difficulty, what we're looking at here isn't a difference in ability, but a difference

in how students cope with experiences that may call their ability into question--whether they feel challenged by them or demoralized by them.

Barbara Licht went on to corroborate these findings. In her subsequent research, with different tasks and different measures, she also found that bright girls—who were at the top of the heap when things went well-- were vulnerable to a loss of confidence and a loss in effectiveness when they ran into difficulty (Licht, Linden, Brown, & Sexton, 1984; Licht & Shapiro, 1982). And, by the way, it is here, at the top of the ability distribution, that the gender difference in math emerges. Thus, it is possible that at least part of the emerging difference in math is a gender difference in coping with setbacks and confusion rather than a gender difference in math ability.

Good News or Bad News?

Is this good news or bad news for the issue of females and math/science? Well, it's good news if the ability is there. But it could be bad news, too. After all, if bright females don't cope as well with challenges, wouldn't this mean that they're not as suited for careers in math and science, careers that involve tackling the most challenging problems known and pursuing them doggedly? This is precisely why we have worked so hard to discover what lies beneath females' greater sensitivity to setbacks. We believed that if we could discover the basis for it, we could change it. Well, we have and we can.

In our recent work, we have pinpointed a psychological basis for the vulnerability, and have shown that interventions that address this factor shrink the gender difference in math performance—both on our tasks and in the real world.

Is Math a Gift or An Earned Ability?

This work starts with students' beliefs about intellectual ability in general and math ability in particular. Do they view it as a gift—an ability that you simply have or you don't? Or do they view it as something that can be developed—something that builds on an initial ability and expands it through practice and dedication?

We had found in our past research that viewing intellectual ability as a gift (a fixed entity) led students to question that ability and lose motivation when they encountered setbacks. In contrast, viewing intellectual ability as a quality that could be developed led them to seek active and effective remedies in the face of difficulty (See Dweck, 1999).

We had also shown that these beliefs about intellectual ability predicted how well students performed across the transition to junior high—a very challenging time, when grades tend to plummet and many students turn off to school (Blackwell, Trzesniewski, & Dweck, 2005). Here, we found that students who viewed their intellectual ability as something they could develop maintained their interest in learning and earned significantly higher grades than their peers who viewed intelligence as a gift—even though the two groups entered junior high with the same past grades and achievement test scores. What's more, the difference in grades increased continuously over the next two years.

When we look within these findings at the gender story, we see that by the end of 8th grade, there is a considerable gap between females and males in their math grades—but only for those students who believed that intellectual skills are a gift. When we look at students who believed that intellectual ability could be expanded, the gap is almost gone. Actually, these males are doing a little better than their fixed ability counterparts,

but the females are doing a great deal better than their counterparts (even though, again, they entered with equal math achievement). This suggests that girls who believe that intellectual abilities are just gifts do not fare well in math, but that those who think they are qualities that can be developed often do just fine.

In a similar type of study, we followed students across the first semester of their pre-med chemistry course at Columbia University (Grant & Dweck, 2003). This highly challenging course plays a large role in who goes on to scientific careers. Here, we found the typical male-female difference in science performance—but, again, only for students who thought of intellectual ability as a gift. For the students who thought of their intellectual skills as something they could develop, the gender difference was *reversed.* The females earned the higher final grades. (As always, we equated for entering ability, in this case by controlling for their SAT scores.)[1]

A picture was beginning to emerge, then, that not all bright females are equally vulnerable. The vulnerability seems to reside more in the ones who see their ability as something that is fixed and that can be judged from their performance—so that when they hit challenges, their ability comes into question: If you have to struggle, then you must not have the gift. If your initial grades are poor, you must not have the gift.

The Gift and the Stereotype

Well, we began to think, females who believe in gifts might not only be more susceptible to setbacks, they should also be more susceptible to stereotypes. After all, stereotypes are stories about gifts—about who has them and who doesn't. So if you believe in a math gift and your environment tells you that your group doesn't have it, then that can be disheartening. But if, instead, you believe that math ability can be

cultivated through your efforts, then the stereotype is less credible. It also seems more like something that can be overcome: “Maybe my group hasn’t had the background, experience, and encouragement in the past, but with the right effort, strategies, and teaching, we should be able to make headway.”

We decided to look at this issue directly. To do this, we followed female students at Columbia University through their calculus course (Good, Dweck, & Rattan, 2005a). This course is a must for virtually all math and science careers. At the beginning of the semester, we found out whether students saw math ability as a gift or whether they saw it as something that could be developed through learning. As the semester wore on, we asked them about whether they experienced gender stereotyping in their math class and we asked them several different times about their sense of belonging in math: When they were in a math setting, did they feel accepted, respected, and comfortable—or not?

We found that many students thought that stereotyping was alive and well in their calculus section. But, happily, this had little impact on women who viewed their math ability as something they could augment. In contrast, feeling surrounded by a negative stereotype had a strong impact on women who thought of their math ability as a gift. Over the course of the semester, their sense of belonging eroded and remained low. They no longer felt accepted and comfortable in their math environment, and as a result, we found, many did not intend to pursue math in the future.

It looks, then, as though the view of math as a gift can not only make women vulnerable to declining performance, it can also make them susceptible to stereotypes, so that when they enter an environment that denigrates their gift, they may lose the desire to carry on in that field. In this way, we were seeing highly able women drop before our

eyes—women at an elite university who began the semester with high interest in math, and who could well have had major careers in math or science.

That's still bad news, but at least we felt we were getting a handle on the psychology behind the vulnerability, which is the first step toward better news.

What Can be Done?

If a big part of the problem is that women seem to lose their confidence in the face of obstacles, how can we give them more lasting confidence? One perhaps obvious solution might be to look for opportunities to praise a female's ability—for example, to watch for occasions on which a woman has done fine work and let her know that she has high ability. This may seem obvious, but it is wrong.

In a series of studies, we have shown that praising students' ability (even after a job truly well done) has a host of undesirable consequences (Mueller & Dweck, 1998). First, it conveys to them that their ability is a gift and makes them reluctant to take on challenging tasks that hold a risk of mistakes. Next, when these same students hit a period of difficulty, the ones who had been praised for their ability tended to *lose their confidence*. If their success meant they had the gift, their struggles now told them they didn't. As a result, they lose interest in pursuing the task (just like females and math) and show a sharp decline in their performance.

So, plainly, covering females with praise for their level of ability is not the answer. Rather than instill lasting confidence, it does just the opposite. So what *would* work? The answer, we found, is to get at the root of the vulnerable confidence by addressing students' beliefs about the *nature* of ability.

To do this, we designed an eight-session intervention for junior high school students that taught them the idea that intellectual skills can be developed (Blackwell, Trzesniewski, & Dweck, 2005, Study 2). We chose the transition to junior high for the intervention because this is a time of challenge for many students, a time of declining grades, and a time when the gender difference in math often emerges. In our intervention (based on one by Joshua Aronson: Aronson, Fried, & Good, 2002), we taught students about the brain, how it forms new connections every time they learn, and how over time this can lead to increased intellectual skills. We also taught them how to apply this lesson to their schoolwork. Students in the control group received an eight-session intervention, as well, replete with high-quality instruction in useful skills, but they did not learn about the expandable nature of intellectual skills.

Before the intervention, both groups showed sharply declining grades in a math, but after the intervention the group that got the "growing ability" message showed a rapid recovery and earned significantly higher math grades than the control group. Teachers (who were unaware that there two different interventions) singled out many more students in our experimental group to say that they showed marked changes in their motivation to learn.

What is most striking for our purpose, however, is what happened to the gender difference in math. In the control group, we observed the typical gender difference, with the girls doing substantially worse than the boys. In the experimental group, that difference almost disappeared. Both groups did well.

A similar study with similar findings was conducted by Good, Aronson, & Inzlicht (2003). They, too, did a "growing ability" intervention with junior high school

students, found higher subsequent achievement for the experimental group than the control group (in their case in achievement test scores), and a greatly reduced gap between males and females in math achievement test scores.

In both of these interventions, then, learning that intellectual skills could be acquired—rather than simply bestowed as a gift—led to important gains in females' math achievement. In essence, the intervention implied: If you want these skills, you can work hard and try to develop them. Girls heard this message and appeared to heed it.

What messages do we send in our math classes and do these subtle messages make a difference? More important, can we use these messages to help females? We (Good, Dweck, & Rattan, 2005b) tried to find this out by teaching adolescents the same math lesson in two different ways. The lesson was a geometry lesson that contained historical information about the math geniuses (Euclid and Reimann) who originated the concepts students were learning. For some students, the "innate ability" and "natural talent" of these mathematicians were highlighted. Although this may seem like innocent enough information—just a way to make a math lesson more interesting-- we wondered whether this would convey to students that math was a gift bestowed upon an elect few and whether this view would make females more vulnerable when they later encountered difficulty.

For the other students, the geometry lesson contained information about the same figures, but portrayed them as people who were deeply interested in and committed to math, and who worked hard and thought deeply to arrive at their contributions. This was meant to convey the idea that, while some people may reach the heights of proficiency (even genius), math ability is something that reaches fruition through effort.

After their lesson, students were confronted with a challenge: they were given a difficult math test, one that was said to measure their mathematical ability. When females had received the lesson that portrayed math as a gift and then experienced this difficulty, they did significantly more poorly than their male counterparts. It was a gift and they, females, must not have it.

However, when females got the lesson that conveyed the idea that math skills are developed, they equaled the males. The difficulty did not undermine their confidence or performance. Thus, it is clear that the messages we send in educational settings really matter, and that through our messages we can help females perform up to their potential.

What Does This Mean?

We have seen that viewing intellectual or mathematical abilities as a gift can create vulnerability in females. It makes them susceptible to a lowered sense of belonging, to a loss of confidence, and to decrements in performance in the face of difficulty and in the presence of stereotypes. However, most important, we have also seen that sending a message that these abilities can be developed can alleviate the vulnerability. Females who heard this message—whether through an intervention or through a lesson that portrayed mathematical ability in this way—remained on a par with males in terms of their math grades, their achievement test scores, and their performance on a very challenging math exam.

As a society, what do we believe? Do we believe in natural talent that needs little work to realize itself—that outstanding ability simply expresses itself automatically? I think many people do believe this, but researchers who study great creative contributions do not. Instead, they emphasize the idea that there is no genius, no great contribution,

without great effort--not for Edison, Darwin, Mozart, or virtually anyone you can name. Despite the "legends," most geniuses put in years of intensive, even obsessive, labor before their potential reached fruition and they made the contributions we know them for (Ericsson, Krampe, & Clemens, 1993; Hayes, 1989; Weisberg, 1999). In many cases, the geniuses-to-be did not even stand out from their peers when they were younger (Israel, 1998; Bloom, 1985)

Perhaps people *want* to believe in innate gifts over earned abilities. That way they can put high achievers on a pedestal and see them as different from others. Well, they *are* different from others, but I'm inclined to put more value on the process that got them there than on some ability they came with. To me, it's far more admirable to achieve something than to have it handed to you. The Polgar family produced three of the most successful female chess players ever. It was not that they showed exceptional aptitude at an early age. Rather, their father decided to work with them. Says one of the sisters, "My father believes that innate talent is nothing, that [success] is 99% hard work. I agree with him." The youngest daughter is now considered the best female chess player of all time, but she was not the one they considered the most talented: "Judit was a slow starter, but very hardworking."

One of the most damaging aspects of the "gift" mentality is that it makes us think we can know in advance who has the gift. This, I believe, is what makes us try to identify groups who have it and groups who don't—as in "boys have it and girls don't." Can anyone say sure that there *isn't* some gift that makes males better at math and science? What we *can* say is that many females have all the ability they need to for successful

careers in math-related and scientific fields and that the idea of the "gift-that-girls-don't-have" is likely to be a key part of what's keeping them from pursuing those careers.

Some say it's important to have an open, public dialogue about inherent differences in abilities, and that this should not be a topic that is off limits to scientific inquiry. Who can disagree with the assertion that it's good to have an open dialogue? Yet, we have seen that some views can harm people by telling them --in advance-- that they don't have the skills and that they don't belong. I believe that the public dialogue and the scientific inquiry are best directed, not at deciding who has math and science ability and who does not, but rather at how best to foster those abilities.

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Footnotes

[1] These data on gender differences were not included in the published article. In some of the other studies discussed, as well, the data on gender differences were not necessarily highlighted or discussed in the final article.