Different, Not Better: Gender Differences in Mathematics Learning and Achievement

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This article reviews the assessment data, literature and research on gender differences in mathematics. The question of whether boys are better at mathematics has been an issue in education for the past 5 years. The assumption is that there is a biological difference between boys and girls that make boys predisposed to do better in mathematics. Data from the National Assessment of Educational Progress disputes this assumption. The NAEP shows a gap of only 2 points between girls and boys and that has developed only in the last decade. This article reviews the literature and research on differences in boys and girls and concludes that there are differences in the way boys and girls learn and process mathematics and that this difference is not being taken into account by our educational system. Suggestions for individualizing the curriculum to meet the needs of both boys and girls in the mathematics classroom are included.

Boys and girls are different. One is not better than the other; they are just different. As a result, we can expect that a difference exists in how boys and girls learning the way they learn. However, in many classrooms, the classroom climate, learning style, instructional style, and experiences offered to boys and girls may not address the needs of either gender. This tunnel-vision view that all students learn in the same way regardless of gender, may be doing a disservice to our students. The problem is that traditional methods of teaching have a negative impact on both girls and boys (Gurian, 1998, 2001, 2002b, 2003a, 2003b, 2005; Kindlon, 2000, 2006; Pipher, 1994; Pollack, 1999a).

The context of classroom climate, teacher attitudes, learning style, instructional style and experiences and activities offered to promote mathematics instruction with young children under the age of 8, need to be addressed to improve outcomes for both sexes. But, how can the needs of both boys and girls in mathematics programs be met?

Mathematics in Schools Today

Mathematics in many classrooms is mostly based on a traditional skills model (Becker, 2003; Bevan, 2001; Brodinsky, 1985; Gamoran, 2003). Too often this means memorization and rote recitation rather than active concept based learning. Imagine a classroom climate that acknowledges gender differences while considering individual styles and behaviors (Forgasz, Kloosterman, & Leder, 2004; Gavin & Reis, 2003). This classroom climate would be supportive of the mathematical learning needs of both boys and girls. An essential element in this approach is planning a curriculum that is developmentally appropriate, individualized, and gender responsive.

Many assumptions are made about differing abilities of girls and boys when it comes to mathematics. While on the 2005 NAEP, girls lag only about 3 points behind boys, this is only a recent phenomenon. In the 1970's, girls actually out performed boys in all but the 12th grade test (Bielinski & Davison, 2001; Carpenter, Brown, & Lindquist, 1988; Loveless & Coughlan, 2004; Perie, Grigg, & Dion, 2005). These assumptions

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about differing levels of ability pervade not just the classroom, but home.

Leedey, Alone, & Rank, (2003) found that many parents expect their young sons to develop mathematical skills earlier than parents of young girls expect their daughters to develop these skills Parents of older children believe that their daughters must work harder to attain good grades in mathematics, while parents of boys place more emphasis on the importance of learning mathematics. Parents, quite naturally, expect different things from their children, but their attitudes and expectations have a direct correlation to their children's achievement in mathematics (Campbell & Clewell, 1999; Campbell, Storo, & Educational Resources Information, 1996; Laster, 2004; Levi, 2000).

In the classroom, research has also shown that girls tend to feel less confident about their answers on tests and often express doubt about their performance. Boys, however, tend to show more confidence and sometimes overconfidence. This uncertainty on the girls part and over-confidence on the boys part often extends beyond individual problems into their general view of mathematics (Ai, 2002; Bevan, 2001; Leedy, LaLonde, & Runk, 2003; Li, 2001; Tiedemann, 2000, 2002). There is evidence that as children progress through the early grades (4th and under), girls' enjoyment of mathematics falls off much more drastically than in boys. The traditional curriculum and pedagogy of schools seem to perpetuate this disparity (Bevan, 2001).

Do all of these expectations ultimately lead to girls "dropping out" of mathematics earlier than boys? Do fewer numbers of girls take higher-level mathematics in High School? The answer according to the NAEP is a resounding "no". In fact, regarding the highest level of math taken by 12th grade boys and girls, the statistics are almost identical. In 1999, girls were actually slightly more ambitious than boys at the Geometry and two-year Algebra level (Perie et al., 2005). Girls have made significant gains, and since the NAEP study began in 1978, they are taking the same levels of math as boys and achieving on the same level. Research shows that even though girls are largely keeping pace with boys, there are significant differences in their experiences in learning mathematics (Bevan, 2001; Tiedemann, 2000, 2002; Wilson, Snapp, & Texas Foundation for Women's, 1992).

So what does this mean for how we teach in our classrooms? It means that we have to be sensitive to the different needs of boys and girls. While their ability and potential to understand higher level mathematics is equal, their brains are different and more importantly, their approach to learning may be different (Allen, 1995; Arnot, Great, & Office for Standards in, 1998; D'Arcangelo, 2001; Gurian, Henley, & Trueman, 2002).

This can make developing a mathematics program difficult because our traditional textbook based curriculum does not lend itself well to an individual approach to teaching. However, there are a number of things that teachers can do to make sure that boys' and girls' needs are met in the classroom regarding mathematics (Tiedemann, 2000, 2002).

10 things teachers can do to support math in both boys and girls

1) Avoid Labeling

It is very easy to assume that girls are bad at math and boys are bad at language. It is also dangerous to think this way (Barnett & Rivers, 2004). Most teachers would never consciously treat boys and girls differently, however assumptions about gender roles and myths about learning mathematics can sometimes lead to us treating boys and girls differently without even realizing it. This is what is know as the "self-fulfilling prophesy." If you think a student is going to succeed, you will treat the child subtly different and because of that subtle difference, the child will most likely live up to your expectations and vice-versa.

Many teachers believe that girls achieve in mathematics due to their hard work, while boy's achievement is attributed to talent (Jussim & Eccles, 1990, 1992; Madon, Jussim, & Eccles, 1997; Smith, Jussim, & Eccles, 1999). These differing expectations by teachers and parents may lead to boys often receiving preferential treatment when it comes to mathematics. Children may internalize these attitudes and begin to believe what their teachers and parents believe. As a result, girls' assessment of their enjoyment of mathematics falls much more drastically than boys' assessment as they move through the grades. These attitudes may shape the experiences that children have as they are learning mathematics.

Teachers and parents should avoid the pervasive gender stereotyping that is prevalent on television and other media. Girls need to resist the "princess" culture where appearance and helplessness are promoted. Positive role models in terms of mathematical ability and thinking will go a long way to developing positive attitudes and abilities in mathematics.

2) Get to know your students learning styles.

In a broad sense, girls tend to be read/write or auditory learners and boys tend to be visual and kinesthetic learners. However, each individual, no matter what his or her gender, will have a preferred learning style and as a teacher or parent, it is important to know what this is so the curriculum can be tailored to the child's strength (Bevan, 2001; Fleming, 2005; Molumby, 2004; Singham, 2003). Find out how each child learns best. Different children may have different ways of approaching mathematics. Teachers need to make sure that their curriculum planning process takes this into account.

Visual learners learn by having things shown to them. They may respond best to drawing things out or seeing a problem on a chalkboard. Auditory learners like to have things explained to them and enjoy talking through problems. These students would respond well to working in groups or having a partner to discuss a problem with. They would also understand the problem better if it were read aloud. Read/write learners learn by reading things. They would like to read problems and read all they could find on how to solve the problem. These children would prefer to have problems written down and a book as a reference. They would also understand mathematics better if it were written and would prefer to turn in written homework. Kinesthetic learners learn by doing. They would like to use objects to solve problems or act out a scenario. Movement and interaction is key to this learning style. These children will understand mathematics best if they can use it to solve everyday problems. While all students may benefit from a hands-on approach, children who are kinesthetic learners, will understand mathematics in this way when other methods of instruction fail for them. Contextualizing and interacting with mathematics is vitally important for these children.

This method requires that teachers re-examine the traditional method of teaching, which emphasizes memorization of steps and procedures to solving specific problems which is so prevalent in U.S. schools (National Center for Education, 1997).

3) Get to know the developmental differences of your children

Developmentally, at birth, boys are a few weeks behind girls and remain behind girls until late adolescence (Gurian et al., 2002). This developmental difference impacts their early school learning experiences and has impact throughout their education. Boys' fine motor skills develop slower than girls and they may have difficulty with handwriting tasks (Pollack, 1999a). Their language and fine motor skills fully mature about six years later than girls (Hanlon, Thatcher, & Cline, 1999). Therefore, when they enter school they

are often less able than girls to write numbers correctly or align numbers for tasks such as adding and subtracting on paper. Girls, on the other hand, find writing and completing worksheets much easier.

Development of the ability to attend also shows variations. Because of the different rates of mylenization of the cerebral cortex, boys may be less able to sit and attend to information for long periods of time. Girls, however, seem better at self-managing boredom; therefore, they tend to be more attentive in class. This is why boys tend to be more vocal and receive the lion's share of reprimands for poor behavior (Gurian et al., 2002; Pollack, 1999b).

Girls are also more willing to learn and see learning as the outcome of their academic work. Girls do better on open-ended, process-based experiences that encourage independent thinking. Boys also tend to get bored more easily than girls thus requiring more stimulation to keep them attentive and on task. Repetitive activities are often difficult for boys to attend to positively (Gurian et al., 2002; Levi, 2000; Pollack, 2002).

Requiring long stints in chairs working quietly may fit a girl's developmental level better than boys. Therefore, we observe more misbehavior from boys. Designing activities and schedules that allow children to manage their boredom in an appropriate manner works best.

4) Allow children to solve problems in many different ways

Because of the variance in developmental levels and learning styles, there may be very different ways that children go about solving a problem. A mathematics program needs to be flexible enough to allow children to use their own natural thinking ability and their strengths to solve problems. Boys and girls have some unique characteristics that make a "one way" approach to solving problems inefficient.

Many of the worksheets and problems presented in textbooks are also not very good at promoting thinking and discussion. These methods don't work as well for both boys and girls in the same way. However, since boys tend to adapt to a transmission model better and function better in a competitive environment (such as number grades on worksheets and tests and teacher recognition), boys have the advantage in a traditional classroom where traditional textbooks are used (Gurian, 2005; Rousso & Wehmeyer, 2001).

For example, boys would be more apt to respond to a model of teaching in which right answers are emphasized. They tend to be focused on reaching a conclusion quickly and, often, individually. Competition, a drive to please the teacher and a satisfaction with completing very clear-cut tasks mean that boys respond to a transmission and textbook based approach better than girls. This does not mean, however, that, this is the best way to present mathematics to children. An analogy might be that children would love to eat candy for dinner, but it is not what is best for their long-term health.

Girls, on the other hand, tend to look for many different ways to solve the same problem. Girls use cooperation more than a competitive approach and are less concerned with being "first" or "best" and more with being sure that the needs of their close friends are met as well as their own. They are more likely to help less competent students on problems.

Teachers have the direct contact with the students and can therefore better develop engaging mathematical activities that are appropriate for both boys and girls needs. The teacher is the decision maker about curriculum. Using a research knowledge base to inform the curricular process will help the teacher design appropriate activities for all the children in the class.

5) Using active and exploratory methods of teaching

Boys are more physically active and like

to engage in more exploratory play (Barnett & Rivers, 2004; Boland & Educational Resources Information, 1995; Campbell et al., 1996). They like to use their bodies to learn. As a result, boys tend to use more personal space to work and play. Because of this physicality, boys tend to be more "rough and tumble" or what is often referred to as "boys being boys". For teachers and parents it is important to understand that this is a boy's way of exploring their environment. They move through it and experience it. They tend to be a bit vigorous in their interaction with objects preferring to throw and bang things rather than collect and hold things as girls might do.

Girls are often less active and use the space provided in the manner specified by the teacher. They tend to use language to reach their goals and deal with problems. For example if another child were to take a toy from a fellow 5 year old, a boy might chase the other child down and grab it back, where as the girls might say "Give that back! I was playing with it. You can play with it when I am done." (Gurian, 2005)

Boys are often unable to verbalize their thought process to teachers or parents in disciplinary matters or in academic matters. For many boys, communicating verbally is not as easy as using actions. Boys will often point or shrug to communicate their thoughts. How many times have teachers and parents heard "I dunno" to a question that began with "Why"? (Newberger, 2000)

Allow boys an outlet for them to interact with mathematics and communicate mathematically through their actions rather than words. Using manipulatives allow boys to show what they know or to demonstrate a problem. Girls have are better at telling teachers or other students what is on their mind than boys. For girls it is easier to use words to explain their actions and understandings of mathematics. This is because girls use language to build relationships. Boys tend to use language to transmit data. In other words girls use "rapport" speech while boys use "report" speech (Santrock, 2005).

6) Visual Spatial versus Language Based approaches to Mathematics

Boys tend to be better at visual-spatial tasks such as mental rotation, spatial perception, and spatial visualization (Halpern, 2004). Boys are also better at quantitative problem solving and tasks that involve maintaining and manipulating a visual image in working memory (Halpern, 1997, 1998, 2002). Boys will excel at tangrams and puzzles and using mathematics to build. Visual problems such as the "figure rotation" problems on many intelligence tests will be more along the lines of what boys are comfortable with.

Girls tend to be better at verbal processing which enables them to retrieve semantic and phonological information in their long-term memory (Halpern, 2004). As a result, girls are better at tasks that require rapid retrieval of information such as learning mathematics skills such as the multiplication table (Halpern, 2004). Girls tend to be the storehouse of knowledge, while boys are more comfortable at applying the knowledge.

7) Developing activities based on different attention levels of boys and girls

Since boys tend to be more active and girls a bit more sedate in classroom settings, it is important to adjust the teaching environment to guard against boredom. A negative side effect of surplus boredom is classroom management problems (Gurian & Stevens, 2005). Bored children tend to act out and cause classroom management problems. Boys usually cause most classroom disruptions as evidenced through school suspensions and expulsions because teachers see their physicality as aggressiveness rather than a way of learning. Boys will find ways to deal with their boredom and many times this becomes negative. Teachers, however can keep boys minds occupied in a positive way by incorporating problem solving and active

learning strategies into the classroom.

Boys are often accused of not following instructions or doing what they have been asked. Often when boys are asked what they are supposed to do, they do not know. This may be because they really did not hear the instructions as well as the girls did because boys tend to hear less well than girls and process sounds more slowly. Therefore, less information goes to the brain of a boy to be analyzed. They are "auditory – inattentive" which makes it difficult for them to pay attention and follow instructions (Newberger, 2000). They may only hear the first sentence even though the teacher might have said two or three sentences. Since girls are better at auditory processing skills, they are better at using language as a learning tool.

Girls tend to talk when they are working and boys work without talking and interacting. Therefore, girls are more likely to listen and follow directions better. Girls seem to like to have things explained in useable, everyday language; whereas, boys find jargon and coded language more interesting (Gurian, 2003a). Pairing boys and girls for tasks that involve a lot of following verbal instructions is helpful to both.

8) Competition versus cooperation

Designing group work also takes special care when it comes to gender differences. Learning mathematics is a social endeavor and interacting with others while problem solving is a good way to make the learning active. There are a few things to remember when designing group experiences.

Girls tend to prefer cooperative learning activities whereas boys prefer competitive ones (Halpern, 2004). Teachers need to make sure that these two seemingly conflicting ways of working are incorporated into group experiences. This can be achieved by allowing the students to use a "task oriented approach". Providing a group a list of tasks that they are responsible for achieving and letting the group decide how to best reach their goals. For example, if a groups task is to build a scale model of their school building out of cardboard boxes, the boys may choose tasks that they can do individually and report back to the group, such as measuring the school buildings outside walls. The boys may even compete with each other to see who can come up with the most accurate way of measuring the wall or who can do it the fastest. Competition tends to be the mode of interaction for boys. Girls, on the other hand, may choose to work together to find materials and discuss how to scale down the measurements. The girls will work for consensus on this matter since they tend to emphasize cooperation.

Also, boys like to be individually rewarded for what they achieve. So they will want the teacher to individually acknowledge their achievements in measuring the building and will value that acknowledgement over any thing the group may receive. They want everyone to know that they are the best (Boaler, 2002; Hall, Davis, Bolen, & Chia, 1999; Levine, 1995).

9) Individual versus Group

Boys tend to like to work alone. They prefer to work independently and in silence. Even in groups they tend to work independently and then report to a group leader (King & Gurian, 2006; Soderman & Phillips, 1986; Yamaguchi & Maehr, 2004). Boys are more individualistic and often like to work alone in competition with themselves or others. Girls, however, tend to focus more on the needs of the group rather than their own needs. They seem to enjoy developing interpersonal relationships with their peers and their teachers, however, boys are less adult oriented and more responsive to their place in their peer environment.

Girls want the whole group to succeed. Their emphasis on cooperation makes it less necessary for individuals to be singled out. However, girls will expect everyone to pull their weight in the group and will get extremely

irritated if someone is not doing what they agreed to do. Given the differences in group work behaviors, this usually leads to conflict between the girls in the group and the boys about credit for the work achieved. Teachers need to make sure there are ways to assess achievement in groups individually and as a cooperative group (King & Gurian, 2006).

10) Inductive versus deductive reasoning

Boys seem to be better at deductive reasoning and abstract thinking; whereas, girls are better at inductive reasoning and concrete thinking (Gurian, 2001, 2002a). Boys reason from the general to the particular or from cause to effect. They use ideas and concepts and later apply those ideas and concepts to problem solving. Deductive reasoning and abstract thinking makes it easier for boys to do better on multiple-choice tests. Girls on the other hand, reason from observations or detailed facts to general principles and benefit from the use of real experiences in problem solving.

If boys tend to learn better from part to whole and girls from whole to part, design a lesson that allows students to arrive at the same answer in many different ways. Have the students share their methods for solving the problem. Open-ended questions that allow students the freedom to reach the solution in their own way and allow for both inductive and deductive reasoning work best for both boys and girls (Halpern, 2002; Spelke, 2005). Here is an example:

Present the children with the following chart and explain that each letter of the alphabet costs a certain amount of money starting with a, which costs $.01 and Z which costs $.26

A	B	C	D	E	F	G
.01	.02	.03	.04	.05	.06	.07
H	I	J	K	L	M	N
.08	.09	.10	.11	.12	.13	.14
O	P	Q	R	S	T	U
.15	.16	.17	.18	.19	.20	.21
V	W	X	Y	Z		
.22	.23	.24	.25	.26		

Ask them questions like how much is their name worth? Who has the most expensive name? Who has the least expensive name? Teachers can also make up other questions that they like dealing with how much words are worth. Here comes the inductive and deductive thinking part. Ask children if they can come up with words that cost exactly one dollar. Boys and girls approach to this problem will differ because of the difference in inductive and deductive reasoning. Over the next few weeks and months, create a poster on the wall somewhere in the room and every time a child comes up with a "one dollar word" have them explain how they discovered it, and put the word on the poster. This activity allows children to think mathematically in ways that they are comfortable whether the child is a boy or a girl.

Gender equity is supported when teachers develop a few thoughtful problems such this one. Another good example is presented in *First graders dividing 62 by 5 a teacher uses Piaget's theory* (Kamii, Clark, Housman, & Teachers, 2000) In this video, children are asked to figure out how many 5 cent erasers can be bought if a student had 62 cents. This method benefits both boys and girls as they can discuss and present their solutions in ways that are understandable to each child. Students also work on fewer problems for a longer period of time, allowing for cooperative discussions and competitive arguments (which ever each child prefers).

Keep in mind the differences between how boys and girls learn and implement and use these differences to your advantage. For example, if we know that boys often are more deductive reasoners and girls are more inductive reasoners, make sure that you have problems that allow the students to use both of these ways of thinking to solve problems. The best problems can be solved in many different ways and by using many different ways of reasoning. These problems are usually called "brainteasers" and are considered to be extra

or bonus work. It is amazing that children usually love these kinds of mathematics problems even if they despise the drudgery of the traditional worksheet.

Conclusion

It is interesting to note, that while there are only slight differences between sexes in NAEP tests that were given 21 years apart, in 1999, girls were *always* out performed by boys in all the grades, whereas in 1978, boys only came out on top in the 12th grade numbers. So we could ask what has changed in the past 20 years. It would seem that the impacts of standards, back to basics approaches and high stakes testing have benefited boys more than girls. This is exactly what we would expect given the differences between boys and girls and the rigidity of the traditional mathematics curriculum that we have discussed.

These results suggest strongly that the question is not whether boys are more capable at mathematics than girls, but rather, how are our teaching practices in mathematics affecting the mathematical learning of boys and girls differently and who is benefiting more. We contend that neither boys nor girls are benefiting from this emphasis on a standardized skills based approach brought about by an overemphasis on proficiency testing and "No Child Left Behind." If you truly want children to excel in mathematics, whatever their gender, their natural learning styles and thinking ability must be utilized.

Children are natural problem solvers no matter what their gender or ethnicity. They may go about solving the problem differently depending on their gifts and preferences and developmental levels, but they all have a natural thinking ability. If they arrive at an incorrect solution to a problem, it is not because they are "dumb" but rather, because they are using their minds and natural thinking abilities differently. Instead of writing off errors as failures we should examine the thinking process moved that child to an answer. You might be amazed at what you find.

Using the approach of focusing on the process of mathematics and problem solving rather than solely on the correct answer will allow a diversity of thinking and the flowering of all sorts of mathematical behavior in boys and girls. By recognizing that boys and girls have unique differences in the way they approach mathematics. These differences do not include a difference in ability. Boys and girls achieve on similar levels. To support excellence in both boys and girls we must design experiences and curriculum that meet the needs of both boys and girls by understanding their uniqueness.

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