ELEMENTARY GIRLS' ATTITUDES TOWARD MATHEMATICS IN MIXED-GENDER AND SINGLE-GENDER CLASSROOMS

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By the time girls are second graders, they may be exhibiting negative attitudes toward math (Cvencek, Meltzoff, & Greenwald, 2011). McFarland, Benson and McFarland (2011) examined girls' math achievement in single-gender and mixed-gender classrooms and suggest that single-gendered formats can help females. In this study, we compare the math attitudes of 168 elementary girls in mixed-gender and single-gender classrooms. Although results suggest that girls in both class types have positive attitudes toward math, there are interesting distinctions.

By the time girls are in second grade, they may already be exhibiting negative attitudes toward mathematics (Cvencek, Meltzoff, & Greenwald, 2011). They may doubt their own ability and believe in the gender stereotype that girls are not good in mathematics. In fact, they may try to "stay under the radar" during math class out of fear of being embarrassed or judged by their peers and the teacher (Beilock, Gunderson, Ramirez, & Levine, 2010). Girls' fears and anxieties toward mathematics may even prevent the math knowledge they do possess to be used to solve problems. In other words, their gender-biased expectations may lead to lower achievement and lower math self-concept.

Girls' mathematics attitudes form as a result of environmental influences, especially those that occur in interactions with parents and teachers (Gunderson, Ramirez, Levine, & Beilock, 2012; Tomasetto, Alparone, & Cadinu, 2011). Dweck (2006) recommends that girls' mathematics perceptions and achievement be encouraged by creating a "growth mindset" instead of a "fixed mindset" in the classroom. In other words, girls tend to attribute boys' math successes predominately to ability, while they attribute their own to extra hard work. When challenged, girls with this mindset tend to give up because they think they will never be good at math. This is what Dweck called a fixed mindset: females demonstrate an initial lack of confidence when math is challenging because they believe that they should not have to work as hard as they do if they are truly smart. As a result, they end up questioning their overall intelligence and mathematical ability because they think that they just are not good at it. In contrast, the goal should be introducing females to a growth mindset: females learn to demonstrate a belief that hard work and effort when things are challenging actually builds confidence because they are learning and progressing by challenging themselves. This then diminishes their belief that boys are the only

smart students in math. Therefore, teachers need to communicate the "growth mindset" with their students in order to increase females' interest, confidence, and achievement in mathematics so that they are more likely to have a positive experience and future in the field (Dweck, 2006).

A key to building girls' interest, performance, and achievement in math and other subjects may be by providing gender-specific classrooms. McFarland, Benson and McFarland (2011) examined girls' math achievement in a single-gender classroom as compared to a traditional mixed-gendered classroom. Their findings suggest that a single-gendered format can help females. They suggest that girls in a single-gender classroom may receive more attention and help. Additionally, math instruction can be better designed to accommodate female specific mathematical needs (McFarland et al., 2011). In this study, we examine the math attitudes of 168 elementary school girls. Specifically, we compare the math attitudes of girls in mixed-gender and single-gender classrooms.

Method

This study examines the mathematics attitudes of elementary school girls enrolled in mixed-gender and single-gender classrooms in a public elementary school. The elementary school houses approximately 650 students in grades preK-5. Of the 650 students, approximately 55% are White, 23% are Black, 16% are Hispanic, 5% are multiracial and 1% are Asian. Approximately seventy percent of the students are eligible for free or reduced lunch. This school has offered single-gender classes as an option for 10 years, beginning in 2004. The school's commitment to differentiated instruction for all students is evident by the various professional development opportunities provided in the area of single-gender pedagogy. These professional development opportunities are open to both mixed-gender and single-gender teachers. Students are assigned to single-gender classes as they are to mixed-gender classes. In both configurations, there is an effort to balance classes with an equal mix of high performing and low performing students as well as students of varying races and ethnicities. Further, parents have the right to place their children in either type of learning environment.

The survey instrument used in the study was adapted from the *Classroom Mathematics Inventory* (Guillaume, 2005). The survey consisted of 10 items including positively and negatively stated items. For example, "I am good at math" and "I like math" are positively stated items, whereas "math is boring" and "math is difficult for me" are negatively stated items. Each survey item included four response categories ranging from strongly disagree to strongly agree. Students responded by checking the box that best described their response to each item. For the analysis, the response categories were collapsed into two categories (agree and disagree) and the percentages of responses in each category were calculated. In addition to the closed-ended survey items, students were asked to sketch what they think a mathematician looks like.

The surveys were distributed in each classroom by a university researcher at the end of the academic school year. While the researchers were careful to present each item in a natural, non-biased manner, they also helped students by clarifying the meaning of the survey items and by providing appropriate examples. The students completed the survey in approximately 15 minutes as the researchers read each item aloud. Students were encouraged to answer openly and asked not to write their names on the survey. To encourage open and honest responses, the students were told that there were no correct or incorrect responses to the items.

A total of 168 girls in 1st through 5th grades completed the survey. As illustrated in Table

1, the distribution of student respondents by grade level ranged from 28 students in third grade to 40 students in first grade. Of the total students surveyed, 79 (47 percent) are girls in mixed-gender classes and 89 (53 percent) are girls in single-gender classes.

Table 1 Student Respondents by Grade Level and Class Type

Grade Level	Mixed-Gender	Single-Gender	Total
First	18	15	33
Second	16	20	36
Third	13	15	28
Fourth	13	18	31
Fifth	19	21	40
Total	**79**	**89**	**168**

Results

Students were asked to respond to a series of items regarding their attitudes towards math Table 2 provides the results of the analysis. As illustrated in the "Total Girls" column of Table 2, girls overall in mixed-gender and in single-gender classes generally reported positive attitudes towards math. For example, in eight of the ten items, more than 75 percent of all students reported positive attitudes towards math. Further, the items with the smallest percent of positive responses for all students were "Math is difficult for me" and "I get nervous when doing math problems" for which approximately 35 percent of the girls agreed. In other words, well over fifty percent of all girls responded positively on each of the ten items. The majority of females in both types of classes indicated that "Math is easier for some students than others" and "I work as hard as I can in math" perhaps due a growth mindset being developed in this school culture.

The responses for girls in mixed-gender and single-gender were similar on 8 of the 10 items. In other words, girls in both learning environments gave positive responses on the items. Fisher's exact test did, however, indicate statistically significant differences between girls in mixed-gender and girls in single-gender on two specific survey items. For the first two items ("I only use math at school" and "Math is boring"), the difference between girls in single-gender and girls in mixed gender responses are statistically significant at alpha=.05 and alpha=.10 respectively. That is, the differences observed between girls in single-gender and mixed-gender classes for these two survey items are not likely due to random sampling error. Fewer girls in single-gender classes (12.4%) reported using math only in school than girls in mixed-gender classes (29.1%). In other words, girls in the single-gender classes indicated that they use math outside of school more than girls in the mixed-gender classes. This may indicate that a larger percent of girls in single-gender classes understand that math is a useful subject that applies to other aspects of their lives. Next, nearly twice as many girls in mixed-gender classes (23.1%) agreed that math is boring compared to girls in single-gender classes (12.4%). Again, this may indicate that girls in single-gender classes have a better understanding of the importance of math than girls in mixed-gender classes perhaps due to more positive and engaging math learning experiences.

Although the results on these two analyses ("I only use math at school" and "Math is boring") are statistically significant using Fisher's exact test at alpha=.05 and alpha=.10, using the Bonferroni correction method for multiple comparisons negates these results. Considering the 10 items as a family of independent measures, we would expect the p-values of the comparisons to be .005 or smaller in order to minimize the probability of rejecting the null hypotheses that there is no difference between the girls in mixed and single-gender

classrooms. While neither of these items is significant at the .005 level, the fact that girls in single-gender classrooms gave more positive responses should not be completely discounted. While the Bonferroni correction method helps account for familywise measurement error, it also reduces the ability to detect important effects (Gelman, Hill, & Yajima, 2012). The bar graphs in Figures 1 and 2 graphically illustrate the differences between the samples of girls in single and mixed-gender classrooms in the study.

While the overall results seem to indicate that girls in both environments are positive about math, we also examined the results for differences in primary and intermediate grades (see Tables 3 and 4) In primary grades (1st and 2nd), the only item that showed a statistically significant difference between girls in mixed-gender and girls in single-gender was item 1 ("I only use math at school"). More than half (52.9 percent) of primary girls in mixed-gender classes agreed with this statement, whereas only 20% of primary girls in single-gender settings agreed. Further, it is interesting to note, that in the intermediate grades (3rd through 5th) the only item that showed a statistically significant difference is item 2 ("Math is boring"). As with item 1, more girls in mixed-gender classes (31.1) agreed with this statement.

When students were asked to sketch what they think a mathematician looks like, girls in single-gender classrooms overwhelmingly

Table 2 Math Attitudes for Single and Mixed-Gender Girls' Classes (Percent Agree and Disagree)

Attitude Item		Single-Gender (n=89)	Mixed-Gender (n=79)	Total Girls (n=168)
Q1. I only use math at school.*	Agree	12.4%	29.1%	20.2%
	Disagree	87.6%	70.9%	79.8%
Q2. Math is boring.**	Agree	12.4%	23.1%	17.4%
	Disagree	87.6%	76.9%	82.6%
Q3. Math is useful.	Agree	88.8%	81.0%	85.1%
	Disagree	11.2%	19.0%	14.9%
Q4. Math is easier for some students than others.	Agree	88.8%	91.1%	89.9%
	Disagree	11.2%	8.9%	10.1%
Q5. Math is difficult for me.	Agree	32.6%	36.7%	34.5%
	Disagree	67.4%	63.3%	65.5%
Q6. I work as hard as I can in math.	Agree	96.6%	98.7%	97.6%
	Disagree	3.4%	1.3%	2.4%
Q7. I get nervous when doing math problems.	Agree	33.3%	32.7%	35.2%
	Disagree	66.7%	62.8%	64.8%
Q8. There is only one way to solve a math problem.	Agree	10.3%	11.5%	10.9%
	Disagree	89.7%	88.5%	89.1%
Q9. I am good at math.	Agree	78.4%	75.6%	77.1%
	Disagree	21.5%	24.4%	22.9%
Q10. I like math.	Agree	83.0%	79.5%	81.3%
	Disagree	17.0%	20.5%	18.7%

*Fisher's exact test p=.012

**Fisher's exact test p=.100

Figure 1 Single-Gender and Mixed-Gender Responses to "I only use math at school" Item

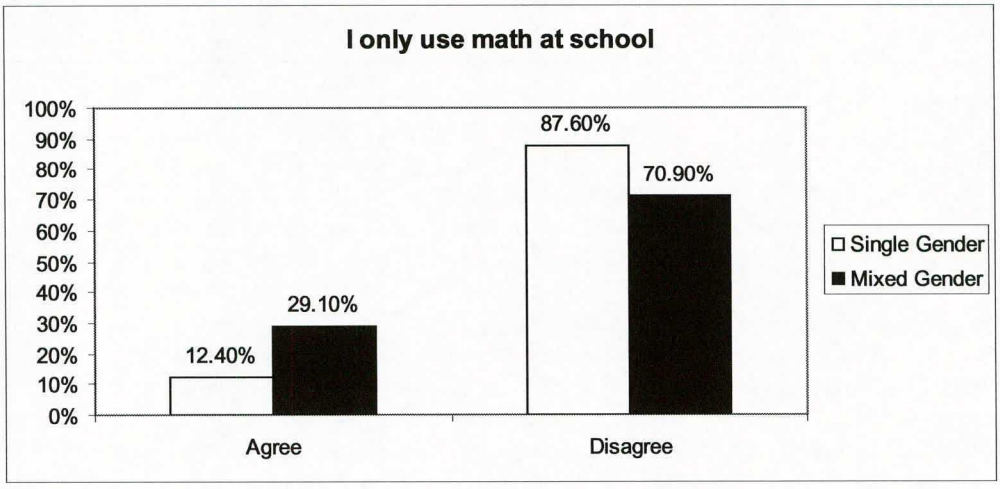

Figure 2 Single-Gender and Mixed-Gender Responses to "Math is boring" Item

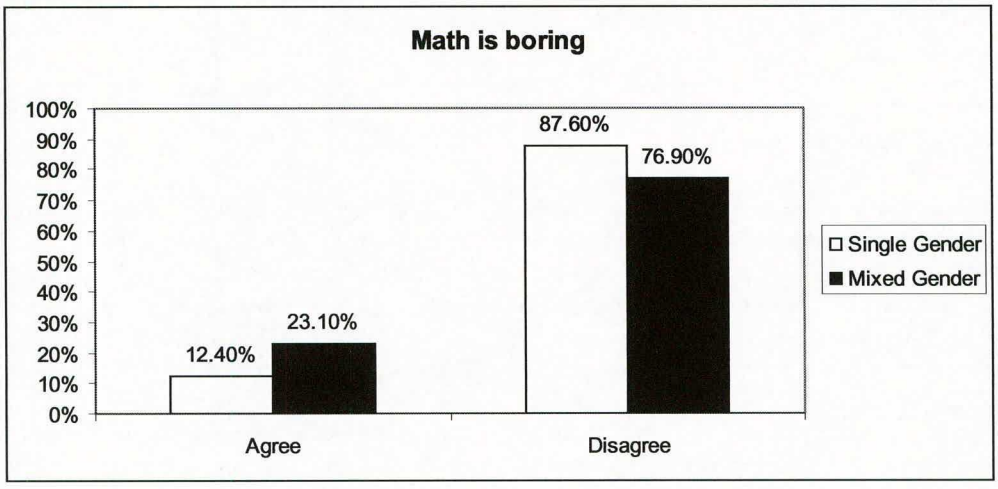

Table 3 Math Attitudes for Single and Mixed-Gender Girls' Classes in Primary Grades 1st and 2nd (Percent Agree and Disagree)

Attitude Item		Single-Gender (n=35)	Mixed-Gender (n=34)	Total Girls (n=69)
Q1. I only use math at school.*	Agree	20.0%	52.9%	36.2%
	Disagree	80.0%	47.1%	63.8%
Q2. Math is boring.	Agree	14.3%	12.1%	13.2%
	Disagree	85.7%	87.9%	86.8%
Q3. Math is useful.	Agree	82.9%	73.5%	78.3%
	Disagree	17.1%	26.5%	21.7%
Q4. Math is easier for some students than others.	Agree	77.1%	79.4%	78.3%
	Disagree	22.9%	20.6%	21.7%
Q5. Math is difficult for me.	Agree	25.7%	32.4%	29.0%
	Disagree	74.3%	67.6%	71.0%
Q6. I work as hard as I can in math.	Agree	94.1%	100.0%	97.1%
	Disagree	5.9%	0.0%	2.9%
Q7. I get nervous when doing math problems.	Agree	30.3%	18.2%	24.2%
	Disagree	69.7%	81.8%	75.8%
Q8. There is only one way to solve a math problem.	Agree	23.5%	18.2%	20.9%
	Disagree	76.5%	81.8%	79.1%
Q9. I am good at math.	Agree	92.1%	81.8%	86.6%
	Disagree	8.8%	18.2%	13.4%
Q10. I like math.	Agree	85.3%	91.2%	88.2%
	Disagree	14.7%	8.8%	11.8%

*Fisher's exact test p=.006

(95%) drew women mathematicians. Of the students in single-gender classes who drew pictures that could be identified as men or women, 76 drew women mathematics while four drew men mathematicians. It is interesting to note that only 70% of girls in mixed-gender classrooms drew women mathematicians. Again, of the pictures that could be identified as men or women, 51 students in mixed-gender classes drew women mathematicians and 22 drew men mathematicians. The most common drawing of women mathematicians included women representing teachers (math books, chalk, children working at desks, and math problems on board were included in pictures). Most women mathematicians were smiling and attractive (hair fixed, jewelry, dresses, heels, etc.). Several students identified their women mathematicians as "just a regular person." Others included quote bubbles with "I love math" or "Math is great." One student in the single-gender 5th grade class drew a picture of a woman architect wearing a hard hat with tools around her. This picture also included a sign that stated "Coming Soon New Hotel." Clearly, this student connects math skills with real-life applications and imagines women using math skills to build hotels.

Conclusion

Overall, the results from this survey suggest that elementary girls in both mixed-gender and single-gender have positive attitudes towards math. While these results are very promising for both mixed-gender and single-gender classrooms, we also found a few

Table 4 Math Attitudes for Single and Mixed-Gender Girls' Classes in Intermediate Grades 3rd through 5th (Percent Agree and Disagree)

Attitude Item		Single-Gender (n=54)	Mixed-Gender (n=45)	Total Girls (n=99)
Q1. I only use math at school.	Agree	7.4%	11.1%	9.1%
	Disagree	92.6%	88.9%	90.9%
Q2. Math is boring.*	Agree	11.1%	31.1%	20.2%
	Disagree	88.9%	68.9%	79.8%
Q3. Math is useful.	Agree	92.6%	86.7%	89.9%
	Disagree	7.4%	13.3%	10.1%
Q4. Math is easier for some students than others.	Agree	96.3%	100.0%	98.0%
	Disagree	3.7%	0.0%	2.0%
Q5. Math is difficult for me.	Agree	37.0%	40.0%	38.4%
	Disagree	63.0%	60.0%	61.6%
Q6. I work as hard as I can in math.	Agree	98.1%	97.8%	98.0%
	Disagree	1.9%	2.2%	2.0%
Q7. I get nervous when doing math problems.	Agree	35.2%	51.1%	42.4%
	Disagree	64.8%	48.9%%	57.6%
Q8. There is only one way to solve a math problem.	Agree	1.9%	6.7%	4.1%
	Disagree	98.1%	93.3%	95.9%
Q9. I am good at math.	Agree	70.4%	71.1%	70.7%
	Disagree	29.6%	28.9%	29.3%
Q10. I like math.	Agree	81.5%	70.5%	76.5%
	Disagree	18.5%	29.5%	23.5%

*Fisher's exact test p=.022

interesting differences between the girls' responses to certain items. Specifically, girls in single-gender primary classrooms responded more positively than girls in mixed-gender primary classrooms on an item that may indicate that girls in single-gender classrooms see themselves as using math outside of school more often. This may reflect teachers who have positively highlighted math and its usefulness, or is a mindset the single-gender teachers were able to foster. Further, girls in single-gender intermediate classrooms responded more positively than girls in mixed-gender intermediate classrooms on an item that suggests math is boring (i.e., mixed-gender girls thought math is more boring than single-gender girls). This finding may suggest that as girls age in the mixed-gender classes they begin to believe the stereotype that boys are naturally smarter in mathematics and begin to have a fixed mindset, whereas girls in single gender classes see math as relevant and useful. The useful and relevance nature of math may empower girls thus developing a more fluid or growth mindset. Further, the growth mindset and perceived usefulness of math may make math less boring for these girls. Moreover, girls in mixed-gender classrooms may have additional pressure of boys in their classes. This finding may support an important philosophical underpinning of single gender education related to the breaking down of gender-specific stereotypes (i.e., that math is for boys). Gender-specific classrooms may help students learn to develop and use their

cognitive processing skills more effectively; in addition, such an environment may provide girls with more attention and help than traditional classrooms (McFarland et al., 2011).

We believe the positive math attitudes for girls are due to the culture of the school that focuses on differentiated instruction for all students, which includes the needs of girls and boys. Professional development opportunities on translating the research on gender differences into teaching strategies and pedagogical practices are available to all teachers (both mixed-gender and single-gender teachers are encouraged to participate).

Regardless of whether the setting is a single-gender classroom or a mixed-gender classroom, girls need an environment that helps them feel accepted and comfortable. We believe the results from this study reinforce Dweck's (2006) findings about the role of mindsets in students' motivation. Teachers need to communicate the "growth mindset" to girls. A growth mindset builds character and confidence by communicating to girls that hard work when things are challenging is how we grow and progress in our learning and, most importantly, in life. Praising effort, rather than ability, helps girls to see math ability as something that is developed through learning—and that setbacks and confusion are a natural part of the process.

Limitations of this research include that it only utilized students from one school that offers a mixed-gender and single-gender option and did not use a pre/posttest design. Future research should incorporate students from multiple schools that do not offer the single-gender classroom model. Future research should also utilize more qualitative models such as focus group interviews with girls and classroom observations in mixed-gender and single-gender classrooms.

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