Student Academic Self-Concept and Perception of Classroom Environment in Single-Sex and Coeducational Middle Grades Mathematics Classes

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In this article, we present findings from a study that investigated the relationship between all-girls classes, all-boys classes, and coeducational classes on student mathematics self-concept and student perception of classroom environment. Further, we compared responses of girls in all-girls classes to girls in coeducational classes and responses of boys in all-boys classes to boys in coeducational classes. Using the Mathematics Attitude Scale and the What Is Happening in This Class? questionnaire, we found no significant differences in student responses on any of the subscales or domains for any of the subgroups, except for Math as a Male Domain. Our findings indicate that student mathematics self-concept and student perception of the classroom environment are similar regardless of whether students are in a single-sex or a coeducational class.

Introduction

In U.S. public schools, academic classes consisting of only girl students or only boy students became permissible in certain circumstances in October 2006. Thus, in contrast to countries such as the United Kingdom or Australia, single-sex classes in U.S. public schools are recent phenomena and questions have risen about whether or not such settings can enhance the learning experiences of either boys or girls—particularly their self-concepts and self-efficacy in mathematics and science. Based on data from the U.S. Department of Education's Office of Civil Rights, there are hundreds of schools that currently offer some variation of single-sex alternatives for academic courses nationwide (Klein, Lee, McKinsey, & Archer, 2014; Office for Civil Rights, 2014). These single-sex alternatives provide scholars with an opportunity to investigate the efficacy of single-sex education in public schools, particularly in instances where schools and districts are implementing single-sex classrooms within coeducational schools, rather than separating boys and girls into different schools. The authors are engaged in studies that seek to contribute to our understandings of to what extent, in what ways, by what means, and for which students, single-sex mathematics and science middle grades classrooms may influence learning environments, classroom discourse, student academic self-concept, and student performance. In this article, we present findings on student perception of classroom environment and student academic self-concept in single-sex and coeducational mathematics classrooms at the middle school level. In particular, we focus on the following questions: To what extent and in what ways are student academic self-concept and student perception of classroom environment related to class type (all girls, all boys, or coeducational)? How do girls in all-girls mathematics classes compare to girls in coeducational (coed) classes in their academic self-concept and perception of classroom environment? How do boys in all-boys mathematics classes compare to boys in coed classes in their academic self-concept and perception of classroom environment?

Literature Review

Inherent in some arguments fomenting the introduction of single-sex education in schools is the notion that, in general, male and female students learn differently (Gurian, Stevens, & Daniels, 2009). Some proponents posit the existence of innate biological differences between boys and girls which impact the way students learn. Understanding such differences, they argue, should help educators create learning environments that take cognizance of the developmental growth of students while developing instructional modules and educational experiences to meet the learning needs of each gendered group (Sax, 2005). As such, they see schools instituting gender-based interventions in coeducational settings as a chance to diminish imbalances in access to educational opportunities by either boys or girls and hope that such settings will serve to increase students' participation and achievement in mathematics and science (Salomone, 2004; Woodward, Fergusson, & Horwood, 1999). It has also been proposed that separating students into single-sex classrooms decreases classroom distractions—especially from students of the opposite sex (Herr & Arms, 2004; Salomone, 2004)—affords boys and girls environments where they feel more at ease, are able to interact with learning, and feel free to show real interest in classroom activities without inhibition (Younger & Warrington, 2006). There is an expectation that, with such benefits, the introduction of single-sex education as a school or class option will lead to higher levels of academic self-concept in male and female students.

Some studies have posited the notion that heterosexual classes are inherently unequal. Adherents of single-sex instruction note that boys in regular coeducational classrooms are more characteristically disruptive with shorter attention spans than girls (Duncan & Schmidt, 2009). In some courses, particularly in mathematics and science, boys are also more likely to seek out and receive teachers' attention, and to volunteer in classroom discussion, while teachers are less likely to ask girls challenging questions, thereby relegating girls to passive behaviors like making suggestions and taking notes (Lee, Marks, & Byrd, 1994; Salomone, 2002). As Pahlke, Hyde, and Allison (2014) note, educators worry that such attitudes might account for the smaller number of female students pursuing Science, Technology, Engineering, and Math (STEM)-related courses. Single-sex educational options are seen to be part of an effort to counter the stereotype threat and empower female students to develop the confidence to pursue mathematics and science courses without discomfiture (Bowe, Desjardins, Clarkson, & Lawrenz, 2015; Mael, 1998; Sadker & Sadker, 1994). Additionally, some educators view single-sex education as a way to address concerns about the academic performance, negative stereotypes, and low expectations of boys in general, and African American and Latino boys in particular (Mulholland, Hansen & Kaminski, 2004; Pahlke et al., 2014; Singh, Vaught, & Mitchell, 1998).

Critics of single-sex education, however, claim that advocates select research studies and distort findings to persuade teachers, parents, and other stakeholders that boys and girls learn differently even though the scholarship– seen in its entirety, does not support such conclusions (Eliot, 2013; Halpern et al., 2011; Harker, 2000; Mead, 2006). For instance, Eliot (2013) argues that by adopting the stance that boys and girls learn differently, researchers negate a basic assertion in child development that, far from being "hard-wired," children's brains are particularly malleable during the formative years and it is this plasticity that plays such a crucial role in how students adapt to their environment and react to everyday experiences. Similarly, Bigler and Signorella (2011) observe that proponents of single sex-education make use of research findings in whatever form—whether from private or public schools— with little consideration for confounding factors, statistical, and methodological weaknesses. As such, without understanding contextual factors surrounding each school's implementation of the single-sex educational program, it would be difficult to generalize findings.

Fueled in part by this lack of scholarly consensus on single-sex education efficacy, there continues to be interest in evaluating the effect single-sex groupings within coeducational schools have on students' perceptions of the classroom environment and of their academic self-concepts in mathematics and science (Brown & Ronau, 2012). In the three decades since Rowe (1988) pointed out the use of single-sex classes as an intervention strategy to increase participation and achievement of either boys or girls in mathematics and science, studies focused on the impact of single-sex instruction on self-concept at the school and classroom level have been equivocal (Belcher, Frey, & Yankeelov, 2006; Jackson, 2002; Smithers & Robinson, 2006; Younger & Warrington, 2006). Whereas some studies have pointed to significant differences in students' self-concept based on the type of educational setting (Kessels & Hannover, 2008; Sullivan, 2009), others have not found any significant differences in comparisons of single-sex settings to coeducational settings (Brown & Ronau, 2012; Riordan, 1990). These murky findings are not restricted to mathematics. Kessels and Hannover (2008) examined male and female's physics-related self-concept and found that, whereas females in a single-sex classroom reported a statistically higher self-concept in physics than females in a coeducational classroom, there were no significant differences for males' physics-related self-concept based on enrollment in a single-sex or coeducation classroom.

In instances where differences have been noted, boys have generally been associated with higher mathematics and science academic self-concepts, whereas girls are reported to show higher verbal- and language-related academic self-concepts (Dai, 2001). These findings are in line with Marsh, Trautwein, Lüdtke, Köller, & Baumert,'s (2005) findings, which posit gender differences, specifically in the domains of English and Mathematics, and argue for correlations between academic self-concept, interest, and achievement in said courses. Additionally, other studies have associated students' perceptions of their academic self-concept and level of learning, suggesting the existence of reciprocal relationships between academic self-concepts, learning strategies, and academic achievement (McInerney, Cheng, Mok, & Lam, 2012). McInerney et al. note that students with high academic self-concepts tended to experience deeper learning and performed better on achievement tests, while the converse was speculated to be true for students with low self-concepts

Few studies have, however, considered the relationship between middle school single-sex and coeducational classroom environments and students' self-concepts (and attitudes) toward mathematics and science. This investigation examines students' academic self-concept and their perceptions of their class environment as they participate in single-sex and coeducational mathematics classrooms.

Theoretical Framework

To shed more light on single-sex educational options in public coeducational institutions, this study explores the relationships between middle school students' mathematics self-concept, perception of the classroom environment, and classroom type (all girls, all boys, or coeducational). The notion of self-concept as a hierarchical, multidimensional construct has been well established (Marsh, 1990; Marsh & Hau, 2004). For this study, in line with Bong and Clark's (1999) assertions, we consider mathematics self-concept to be inclusive of both cognitive and affective components and to represent one's perspective of one's competence within the domain of mathematics. Marsh and Craven (2006) discuss the importance of distinguishing between academic and non-academic components of self-concept. They also emphasize that, even within a notion of academic self-concept, domain-specific distinctions of academic self-concept make sense because, for instance, one's mathematics self-concept may not necessarily be correlated with one's English self-concept (see also Marsh & Yeung, 1997). Bong and Skaalvik (2003) concur with the utility of domain-specific self-concept constructs, as they discuss how "academic self-concept reflects an aggregated judgment or overall impression of one's competence in given academic domains" (p. 29). It is likely that these domain-specific self-concepts will have different behavioral and motivational consequences for students' academic performance (Heyman & Dweck, 1998.) Understanding how children learn to develop patterns of self-concept associations with different subjects, then, becomes important because, as Eccles and others have shown, students with diminished subject specific self-concept seldom pursue courses of study or occupations that are mismatched with their academic self-concepts (Denissen, Zarrett, & Eccles, 2007; Frome, Alfeld, Eccles, & Barber, 2006). Furthermore, Cvencek, Meltzoff, and Greenwald (2011) observed that mathematics gendered stereotypes develop early and differentially influence boys' and girls' self-identification with mathematics long before students participate in formalized performance-related assessments that reveal differences in mathematics achievement.

Our focus on middle school students is driven by our understanding of the middle grades—spanning approximately ages 10–15—as a critical juncture in the development of students' knowledge and attitudes toward mathematics (Ma & Kishor, 1997). During this period, students transition from arithmetic to mathematics courses such as algebra—a gateway to advanced mathematics and ultimately college (Stinson, 2004). In a white paper entitled *Mathematics Equals Opportunity*, the U.S. Department of Education notes:

> Students with a strong grasp of mathematics have an advantage in academics and in the job market. The 8th grade is a critical point in mathematics education. Achievement at that stage clears the way for students to take rigorous high school mathematics and science courses—keys to college entrance and success in the labor force. (Riley, R.A. as cited in Stinson, 2004, p. 11)

While it can be illuminating to understand more about student academic self-concept in a variety of classroom settings, it is also meaningful to inquire about student perceptions of the learning environment, particularly when those learning environments are novel to the typical schooling contexts. Variously, perceptions of the classroom environment by both students and teachers have been recognized as the tone, atmosphere or climate that permeates specific classroom learning contexts, as characterized by the social, organizational and instructional components of the classroom processes (Hamre & Pianta, 2010). The importance of student perception of classroom environment has become so clear that an entire field devoted to the study of learning environments is now well established. Dorman, Adams, and Ferguson (2003) report that several studies spanning three decades have linked the quality of the classroom environment to learning outcomes in mathematics. In addition, Fraser's (1998) study notes the possibility that classroom environment could vary by school type (coeducational, boys' and girls' schools). In this study, we investigate whether and to what extent student perception of the mathematics classroom environment is related to classroom type (coeducational, all boys, and all girls) within coeducational public middle schools.

Methods

Context of the Study

A total of 215 students enrolled in one of the three class types (all boys, all girls, and coeducational classrooms) in two rural middle schools (grades 6–8) from one school district in the southeastern region of the United States participated in the study. Fifty-one of these students were enrolled in the 6th grade, 81 in the 7th grade, and 83 in the 8th grade level. More specifically, 85 participants were enrolled in all-boys classes, 66 in all-girls classes, and 64 in coeducational classes (40 boys and 24 girls). Thus, there were a total of 125 boys and 90 girls participating in the survey. Of these, 87% self-identified as white, 6% were African American, 5% were Hispanic, and 2% identified as Native American or Pacific Islander students. Participation in single-sex classes was by opt-in rather than placement as required by provisions from the Title IX amendments. This resulted in a quasi-experimental design with no random preselection processes. All students consented to completing the electronic survey prior to participation. The students completed an electronic survey midway through the spring semester and responded to subscales from two survey instruments—the *Fenemma-Sherman Mathematics Attitudes Scales (MAS)* and the *What Is Happening in This Class? (WIHIC)* questionnaire. The former scale addresses the research questions related to student mathematics self-concept, and the latter scale addresses the research questions related to student perceptions of the classroom learning environment. Both instruments are discussed in more detail below.

Measures

The *Fenemma–Sherman Mathematics Attitudes Scales* (MAS) (Fenemma & Sherman, 1976) have long been used to investigate students' attitudes and beliefs toward mathematics across all levels of schooling. For the purposes of this study, we focus on four of the nine domains of the MAS; the Math as a Male Domain Scale, the Confidence in Learning Mathematics Scale, the Mathematics Usefulness Scale, and the Teacher Scale. The Mathematics as a Male Domain scale is intended to measure the degree to which students see mathematics as a male or neutral domain by asking questions related to how students see mathematics in terms of (a) the relative ability of the sexes to do well in mathematics; (b) the masculinity/femininity of those who achieve well in mathematics; and (c) the appropriateness of the study of mathematics by the two sexes. An example item is "I would trust a female just as much as I would trust a male to solve important math problems." We scored responses on the scale such that low scores stereotyped mathematics as a male domain, while high scores indicated a disagreement with the notion of mathematics as a male domain. The Confidence in Learning Mathematics scale is intended to measure how confident students are in their ability to learn and to perform well on mathematical tasks. The measures range from distinct lack of confidence (1), to definite confidence (5). One such item is "I am sure I could do advanced work in math." It does not, however, measure students' mathematical anxiety and problem-solving skills. The Mathematics Usefulness scale measures the extents to which students believe mathematics would be useful in their current context and in relationship to their future education and aspiration. An example item is "I'll need a good understanding of math for my future work." Finally, the Teacher Scale measures how students perceive teachers' attitudes, interests, and confidence in them as learners of mathematics. A sample statement includes, "I have a hard time getting teachers to talk seriously with me about math." Each scale comprised of 12 statements, with the exception of Math as a Male Domain, which has 11 statements. Furthermore, within each scale there are 6 positive statements and 6 negative statements; hence, all negative statements were reverse coded. The MAS is organized as a 5-point Likert scale from strongly disagree to strongly agree. Again, for the subscale Mathematics as a Male Domain, we coded items so that a high rating reflected rejection of the notion that mathematics is a male domain. Thus, a score higher than neutral (higher than 3 on the 5-point scale) represents disagreement with the idea that mathematics is a male domain, whereas scores lower than neutral represent agreement with the idea that mathematics is a male domain. Fennema and Sherman (1976) obtained split-half reliabilities ranging from .87 to .93 for these scales.

The *What Is Happening in This Class?* (WIHIC) questionnaire was developed by Fraser, Fisher, and McRobbie (1996) as an instrument to assess student perceptions of their classroom learning environments. By incorporating scales that have been shown to be important predictors of learning outcomes, this instrument reflects recent cognitive views of learning in mathematics and science (Kim, Fisher, & Fraser, 2000). The WIHIC contains seven scales or subsets, each consisting of 10 items on a Likert scale: (a) Student Cohesiveness, (b) Teacher Support, (c) Involvement, (d) Investigation, (e) Task Orientation, (f) Cooperation, and (g) Equity. Fraser (1998) notes that it is important to separate variations of a survey that asks about students' perceptions of the classroom environment as a whole from variations of that survey that ask about that particular student's experiences in the classroom; he advocates for extricating these

Table 1
Descriptive Statistics Single-Sex and Coeducational Classroom Settings

	Single-sex			Coeducational		
	n	*M* (*SD*)	95% CI	*n*	*M* (*SD*)	95% CI
Girls—MAS	66	3.79 (.49)	[3.67, 3.91]	24	3.72 (.48)	[3.51, 3.92]
Boys—MAS	85	3.66 (.56)	[3.53, 3.78]	40	3.61 (.58)	[3.42, 3.80]
Girls—WIHIC	63	2.76 (.67)	[2.59, 2.93]	24	2.71 (.54)	[2.48, 2.94]
Boys—WIHIC	71	2.70 (.68)	[2.54, 2.86]	38	2.75 (.59)	[2.55, 2.95]

perspectives into separate class and personal forms. In this study, we use the personal form because we are interested in subgroup analysis (Fraser, 1998). Fraser (1998) reports alpha reliabilities of more than .80 for each subscale for the WIHIC instrument. A cross-national validation of the WIHIC determined it to be a valid measure of the classroom environment with Cronbach coefficient alphas ranging from .76 to .85 (Dorman, 2003).

Data Analysis

Data were screened for accuracy of input and missing values. Further, we examined the distributions of students' scores for girls and boys in single-sex classes and in coeducational classes and found them to be sufficiently normal, with skewness values between −.906 and .871, and kurtosis of −.727 and 1.736. For scoring purposes on the MAS, items means and overall scale means scores are reported on a range of 1–5, with 1 representing lower levels of mathematical usefulness, confidence, and students' low perception of their teacher's attitudes toward them as learners of mathematics. A high score of 5 shows strong positive attributes on the three scales. On the Mathematics as a Male Domain scale, a mean score per item or scale that is greater than 3 (>3) represents disagreement with the notion of mathematics being a male domain, whereas a low score (<3) stereotypes mathematics as being a male domain. Items on the WIHIC were reported on a range of 1–4; with a low response of 1 implying students seldom feel this way in class, and a high response of 4 indicating students always feel this way about a particular survey item within their classroom environments.

Table 1 shows descriptive statistics for each classroom setting, together with the respective 95% confidence intervals, based on overall scores on the MAS and WIHIC instruments.

Data were then analyzed to explicate three interrelated questions. First, we examined the extent to which student academic self-concept and student perception of classroom environment were related to class type (all girls, all boys, or coeducational) using univariate analysis of variances (ANOVA). The dependent variables were the student responses to items on each scale. The independent variables were class type, more specifically an all-girls, an all-boys, and a coeducational class setting. For ANOVA in which a significant difference ($\alpha = .05$) among the means was concluded, Tukey's HSD Pairwise Comparison post hoc test was utilized.

Second, we examined differences in students' perception of academic self-concept and classroom environment by students of the same sex but who were enrolled in either single-sex or coeducational classes. We compared responses to survey items by girls in all-girls mathematics classes ($n = 66$) to girls in coeducational (coed) classes ($n = 24$) using a two-sample independent *t*-test. Similarly comparisons were made between boys in all-boys classes ($n = 85$) and boys in coeducational classes ($n = 40$). The *t*-test is often used to expose significant differences between any two groups on the same variable that have independent observations (Ware, Ferron, & Miller, 2013). Further, Cohen's *d* computations were performed and results analyzed based on Cohen's (1992) guidelines. The independent variables were class type, more specifically girls in single-sex classes compared to girls in coeducational classes, and boys in single-sex classes compared to boys in coeducational class settings. The dependent variables were the student responses to items on the MAS and WIHIC scales. Analyses were done at both at the scale and item levels. All statistical calculations were performed using the software program JMP Pro 10.

Results

The research questions for this study were: To what extent and in what ways are student academic self-concept and student perception of classroom environment related to class type (all girls, all boys, or coeducational)? How do girls in all-girls mathematics classes compare to girls in coeducational (coed) classes in their academic self-concept and perception of classroom environment? How do boys in all-boys mathematics classes compare to boys in coed classes in their academic self-concept and perception of classroom environment? In presenting our findings, we

Table 2
Mathematics Attitude Scale by Class Type

	All Girls		All Boys		Coed			
Subscales	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*-value	*p*
1. Confidence in Learning Math	3.60	.92	3.63	.87	3.52	.86	.277	ns
2. Mathematics Usefulness	3.93	.71	3.87	.69	3.74	.75	1.138	ns
3. Teacher Perceptions	3.48	.68	3.46	.72	3.51	.73	.443	ns
4. Math as a Male Domain	4.08[a]	.52	3.63[b]	.61	3.85[a]	.54	11.722	<.0001
When a woman has to solve a math problem, she should ask a man for help.	4.13[a]	1.19	3.41[b]	1.18	3.82	1.02		.0012
Women who enjoy studying math are a little strange.	4.22[a]	1.14	3.58[b]	1.13	3.94	1.05		.0023
Women certainly are smart enough to do well in math.	4.56[a]	.76	4.07[b]	.87	4.33	.91		.0036
I would have more faith in the answer for a math problem solved by a man than a woman.	4.13[a]	1.19	3.41[b]	1.18	3.82	1.02		.0008
OVERALL	3.76	.51	3.65	.56	3.65	.54		ns

Note. *M* = Mean; *SD* = Standard Deviation; Coed = Coeducational Math Class. Significant difference based on *F*-test with $p < .05$. Item means with a different letter superscript indicate significant difference based on *F*-test with $p < .05$.

address the research questions relating to mathematics self-concept first, followed by our findings addressing student perception of classroom environment.

Findings from the Fenemma–Sherman Mathematics Attitudes Scales

We began our analysis of mathematics self-concept by investigating overall mathematical differences in self-concept among the three class types (i.e., all-girls, all-boys, and coeducational classes), using ANOVA, and no significant difference was concluded (F (2, 212) = .9749, p <.05). Further analysis of the results by scale revealed no significant differences in the responses of students in all-boys, all-girls and coed classrooms for three of the four MAS scales: Confidence in Learning Mathematics, Mathematics Usefulness, and Teacher scales. The Mathematics as a Male Domain scale, however, indicated significant differences, with all-girls and coed classes scoring differently from all-boys classes. Analysis of the 47 MAS items indicated that responses from students in all girls' classes differed significantly from responses from students in all-boys classes on four items of the Mathematics as a Male Domain scale. Table 2 shows results of the analysis of mathematics self-concept by classroom type. In this and subsequent tables, italicized statements indicate specific items within each scale (or subscale) where statistically significant differences were noted.

Our second layer of analysis of mathematics self-concept investigated whether girls in all-girls classes responded differently from girls in coed classes, and how responses from boys in all-boys classes compared with those from coed classes. There were no statistically significant differences on any of the four subscales for girls in single-sex classes and girls in coed classes (see Table 3). There were two individual items on the Mathematics Usefulness scale and the Math as a Male Domain scale on which girls in single-sex classes and girls in coed classes differed significantly; those items are included in Table 3. Similarly, we analyzed survey responses from boys in coeducational classes and compared these to responses from boys in single-sex classes. There were no statistically significant differences on any of the four subscales for boys in single-sex classes and boys in coed classes (see Table 3). One item on the Mathematics Usefulness scale differed significantly for boys in coeducational classes as compared to those in single-sex classes.

In either case (girls in coed v. girls in single-sex, or boys in coed v. boys in single-sex), consideration of the overall self-concept scores reveals no statistical differences between students in either type of classroom setting. Furthermore, looking at the Cohen's d calculations, we see that in each of the four scales, students in single-sex classrooms generally had marginally higher scores than students in coeducational classrooms.

Findings from the What Is Happening in This Class? Questionnaire

To address our research question regarding student perception of classroom environment in single-sex and coed classes, we first compared responses to the WIHIC survey across the three-class types (all boys, all girls, and coed). We found no significant differences across the three class types for any of the subscales or individual items on

Table 3
Coed by Single-Sex Classroom Comparisons by Student Sex

Subscales	Female Coed *M*	Female Coed *SD*	Female Single-Sex *M*	Female Single-Sex *SD*	*t*	Cohen's *d*
1. Confidence in Learning Math	3.54	.77	3.63	.92	.6625	.094
2. Mathematics Usefulness	3.71	.79	3.93	.72	.1965	.291
I will use mathematics in many ways as an adult.	3.50	1.02	4.05	.93	.0192	.564
3. Teacher Perceptions	3.63	.58	3.50	.67	.3948	.207
4. Math as a Male Domain	4.01	.45	4.14	.42	.2303	.247
Studying math is just as good for women as for men.	4.17	.82	4.53	.67	.0346	.481
Female Overall	3.72	.48	3.79	.49	.5209	.245

	Male Coed *M*	Male Coed *SD*	Male Single-Sex *M*	Male Single-Sex *SD*	*t*	Cohen's *d*
1. Confidence in Learning Math	3.52	.92	3.64	.88	.4738	.111
2. Mathematics Usefulness	3.76	.74	3.89	.69	.3969	.154
Math is not important for my life.	3.40	1.43	3.89	1.06	.0340	.389
3. Teacher Perceptions	3.43	.80	3.46	.72	.8433	.013
4. Math as a Male Domain	3.76	.57	3.64	.61	.2927	.248
Male Overall	3.61	.58	3.66	.56	.6957	.052

Note. *M* = Mean; *SD* = Standard Deviation; Coed = Coeducational Math Class. $t < .05$.

the survey. The results for this analysis at the subscale level are presented in Table 4.

Table 5 shows the results of our analysis of girls' responses to the WIHIC instrument in coed classes and girls' responses in all-girls classes. None of the subscales indicated significant differences in the responses, although one item showed significance. Concomitantly, results of our analysis of boys' responses in coed classes compared to boys' responses in all-boys classes are presented in Table 5. None of the subscales indicated statistically significant differences, although one item on the cooperation subscale showed significant differences. That item is included in Table 5.

Discussion

The main goal of the present study was to examine the relationships between students' perception of their mathematics in single-sex and coeducational classes classroom environment and their mathematical self-concept. This study is important because single-sex classrooms in public schools have been allowed since late 2006 in the United States, although the empirical research on potential influences of such classroom settings in the United States is still limited. Because such settings are now allowed, and because many schools and districts are implementing single-sex instruction, we have the opportunity to understand more about mathematics teaching and learning in single-sex (and coeducational) classrooms in the United States.

As the results from our targeted, focused study indicate, student self-concept, assessed through the Mathematics Attitude Scales, was not significantly different for the subscales Confidence in Learning Math, Mathematics Usefulness, or Teacher Perceptions. The only subscale that showed statistically significant differences between single-sex classes was Math as a Male Domain. Irrespective of the method of disaggregation of data and analysis, students in all-girls classes scored higher than students in all-boys and coeducational classes on the Math as a Male Domain subscale, indicating a strong agreement with positively stated questions and strongly disagreeing on negatively stated statements when compared to the all-boys and coeducational classes. Thus in our study, female students in all-girls classes tended to reject more strongly the notion that math is a male domain than students in all-boys classes and students in coeducational classes. However, when students in all-girls classes were compared to female students in coeducational classes (and concomitantly students in all-boys classes compared to male students in coeducational classrooms), no significant differences were noted on all four self-concept scales. This would imply that female students were more likely to resist the notion that math is a male domain than their male counterparts, irrespective of the class setting. The lack of

Table 4
WIHIC by Class Type

	All Girls		All Boys		Coed			
Subscales	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*-Value	*p*
Social Cohesiveness	3.05	.74	3.02	.67	3.07	.65	.0765	.9264
Teacher Support	2.48	.85	2.55	.84	2.43	.79	.3432	.7099
Involvement	2.55	.86	2.58	.76	2.51	.76	.1365	.8725
Investigation	2.34	.85	2.45	.83	2.32	.82	.4596	.6322
Task Orientation	3.14	.84	2.94	.80	3.06	.74	1.0244	.3610
Cooperation	2.96	.88	2.76	.77	2.91	.73	1.1590	.3160
Equity	2.66	.93	2.79	.87	2.85	.80	.7343	.4812
OVERALL	2.73	.69	2.72	.66	2.73	.57	.0102	.9898

Note. *M* = Mean; *SD* = Standard Deviation; Coed = Coeducational Math Class. Significant difference based on *F*-test with $p < .05$.

differences in female students' responses for female students in all-girls classes and female students in coeducational classes indicates that females in general, regardless of the class type, rejected more strongly the notion that math is a male domain than did male students in this study.

These indications from the MAS, that class type does not influence academic self-concept for students in the study, are mirrored in findings from the What Is Happening in This Class? (WIHIC)? survey instrument. Our findings at the subscale level of the WIHIC survey suggest that class type, whether coeducational, all boys, or all girls, did not influence student perception of the classroom environment. None of the subscales were found to be significantly different across the different methods of disaggregation of

Table 5
WIHIC Coed by Single-Sex Comparison by Student Sex

	Female Coed		Female Single-Sex			
Subscales	*M*	*SD*	*M*	*SD*	*t*	Cohen's *d*
Social Cohesiveness	3.01	.71	3.07	.73	.7365	.0804
Teacher Support	2.46	.79	2.50	.85	.8350	.0501
Involvement	2.36	.80	2.58	.84	.2860	.2576
Investigation	2.05	.86	2.37	.84	.1174	.3813
I solve problems by using information obtained from my own investigations.	1.83	.98	2.42	1.05	.0218	.5735
Task Orientation	3.16	.72	3.18	.79	.9109	.0271
Cooperation	2.91	.79	2.99	.84	.6970	.0941
Equity	3.00	.80	2.68	.93	.1398	−.3649
Female overall	2.71	.54	2.76	.67	.7525	.0759

	Male Coed		Male Single-Sex			
	M	*SD*	*M*	*SD*	*t*	Cohen's *d*
Social Cohesiveness	3.11	.61	3.01	.68	.4595	−.1492
Teacher Support	2.41	.79	2.53	.84	.4548	.1508
Involvement	2.60	.74	2.55	.78	.7591	−.0619
Investigation	2.49	.75	2.42	.85	.6508	−.0915
Task Orientation	3.00	.75	2.92	.83	.6290	−.0983
Cooperation	2.90	.69	2.73	.79	.2624	−.2270
When I work in groups in this class, there is teamwork.	3.05	.90	2.67	.96	.0463	−.4062
Equity	2.75	.80	2.78	.88	.8810	.0302
Male overall	2.75	.59	2.70	.68	.6902	−.0803

Note. *M* = Mean; *SD* = Standard Deviation; Coed = Coeducational Math Class. $t < .05$.

data. Even though there were marginal variations in scores on the WIHIC scales by students in this study, there are indications that classroom organization had little relation to students' perceptions of their classroom environment and how they saw themselves as mathematics students.

Though previous studies have shown affordances for students who participate in single-sex settings, as compared to coeducational classes, research that demonstrably indicates variations in students' academic self-concept based on classroom organization remain scant (see Pahlke et al., 2014). As Marsh et al. (2005) suggested, academic self-concept can be predictive of a student's subsequent academic achievement, even after measures of academic interest, grades, and achievement test scores have been taken into account. For proponents looking to introduce single-sex educational settings as a way to promote students' engagement and participation in mathematics and the sciences, this notion can be very enticing, especially given that some studies have, for example, found significant differences between female participants' self-concept based on class-type (e.g., Kessels & Hannover, 2008). However, without knowledge of contexts, demographic information, and related covariate information, it would be hard to make the connection between students' self-concepts and the single-sex settings. Indeed, as Sullivan (2009) points out, inferences from studies on single-sex education are notoriously difficult to generalize across different settings because much of the reasoning behind their implementation is highly context dependent (Sullivan, 2009).

Whereas we acknowledge that variations in schools' structures, cultures, and norms have the potential to influence how single-sex instruction programs are implemented, continued interest in such classroom structures raises broader questions on other factors besides class type that would differentiate single-sex from coeducational class environments. More specifically, whether there is a relationship between teachers' biological sex, and students' affect in single-sex classes. For instance, would it make a difference if students in all-girls or all-boys classes were taught by a male or female teacher? And to what extent are ostensible gender-specific pedagogies (Sax, 2005; Younger & Warrington, 2006) related to students' self-concept, performance, engagement, or discourse? These are important questions that call for further examination of contextual factors inherent within single-sex classroom environments. This study did not make such connections due to limitations associated with access to a small number of teachers and their students, and the omission of teacher demographic information from the survey instrument. Moving forward, in addition to gathering more data on single-sex academic and social environments, it will be necessary to isolate other environmental factors besides class type, and conduct longitudinal studies to better understand students' dissimilarity in attitude toward mathematics and science in single-sex classes overtime.

Conclusions

Our comparisons of girls in coed to girls in single-sex classes and boys in coed to boys in single-sex classes indicate that, on the subscale or domain level, single-sex education did not significantly influence student mathematics self-concept or student perception of the classroom environment. That is to say, we have not found that girls in all-girls classes (or boys in all-boys classes) have significantly different views of their classrooms or themselves as mathematics learners than girls and boys in coeducational classes. However, we realize that the presence or absence of a relationship between class type, academic self-concept, and student perception of classroom environment is not the sole rationale for instituting single-sex education. For this reason, our research team continues to investigate classroom discourse, student performance, and student engagement in single-sex and coeducational classrooms in addition to self-concept and perception of classroom environment.

Many questions and considerations remain regarding the utility or wisdom of separating students according to their biological sex. Some of these issues include whether students' academic performance may be related to class type, whether student attitudes toward STEM fields are related to class type, whether professional development for teachers to implement single-sex instruction influences how students relate to the discipline, and to what extent gendered stereotypes regarding STEM fields are reified or refuted in single-sex classes. These questions will take time to rigorously examine; this study offers measured insight regarding student academic self-concept and students' perceptions of the classroom environment.

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