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Arguing Separate but Equal: A Study of Argumentation in Public Single-Sex Science Classes in the United States

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ABSTRACT

Amended federal regulations have attempted to expand the circumstances in which single-sex classes are permissible in public schools in the United States. Applying a grounded theory methodology, this ethnographic study investigated students' grades and the discursive practice of argumentation in an all-boy and an all-girl science class taught by the same teacher at a public co-educational middle school in the United States to explore whether they learned the same science. Although the classes received similar grades, the boys gained greater exposure to argumentation, a skill that could assist them in future science pursuits. The emerging theory is that single-sex settings can construct differences between the sexes, possibly aiding the development or maintenance of differences between boys' and girls' interest and performance in science. This study highlights the concern that the recent increase in single-sex offerings in the United States could impact equity goals and gender-related outcomes.

KEYWORDS

Single-sex education; middle school; argumentation; public schooling; gender differences; equity

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INTRODUCTION

Recent amended federal regulations have attempted to expand the circumstances in which single-sex[1] classes are permissible in public schools in the United States, enabling the number of public schools that have single-sex offerings to increase (U.S. Department of Education, 2006a). While some countries, such as England, have seen a dramatic decrease in the number of single-sex schools, the National Association for Single-Sex Public Education reports that as of December 2010 there were at least 520 public schools in the United States offering single-sex opportunities, up from just four public schools in 1998 (Dee, 2006; Jackson, 2010; National Association for Single Sex Public Education, 2011; Younger & Warrington, 2007).

A variety of rationales have been presented to support expanding single-sex opportunities in the United States (see Glasser, 2008), including that these offerings might benefit girls in science, especially in the middle grades when significant gaps begin appearing between male and female students' performance in, and attitudes towards, science education (American Association of University Women, 1992; Campbell et al., 2000; Catsambis, 1995). Although these claims exist, there has been a lack of quality research exploring these settings and research syntheses have concluded that there is little evidence to strongly support endorsing single-sex programs over co-educational ones (Arms, 2007; Mael, 1998; Salomone, 2006; U.S. Department of Education, 2005).

What actually transpires in such sex-segregated settings and how might these happenings affect students' science education and reported gender differences in science? As part of a larger project, this ethnographic study investigated one such offering, focusing on two single-sex middle school science classes (one all-boy and one all-girl), within a co-educational school, which were taught by the same teacher. The study explored grades and argumentation as means of discussing whether the two classes learned the same science.

BACKGROUND

Science Education

Although differences in boys' and girls' science course taking in the United States have shrunk during the last decade, male students are still more likely to complete undergraduate and doctoral programs in science (Committee on Maximizing, 2007; Freeman, 2004). Some of these differences might have roots in middle school where many differences in science are first observed or grow more dramatic (Eliot, 2009). For example, reporting on trends in the National Assessment of Educational Progress (NAEP) 1996 science assessment scores, Campbell et al. (2000) highlighted that although boys and girls were found to perform equally well on this standardized measure in elementary school, middle school boys significantly outperformed middle school girls and these differences persisted through high school. The American Association of University Women (1992) and Catsambis (1995) reported that the appearance of this gap in science achievement during middle school coincides with a time when girls' science self-concept and attitudes towards science declined. Given that science can serve as a gateway to many lucrative jobs and professional opportunities, these sex differences have great educational, economic, social, and political importance (Fennema, 1990; Freeman, 2004).

The purported reasons these differences arise are as varied as the people writing about them. Some people argue that biology greatly impacts behavioral and cognitive differences between boys and girls, but disagree on the exact role biology plays (Eliot, 2009; Gurian et al., 2001; Sax, 2005). For example, Sax (2005) claims that innate differences are responsible for leading boys and girls to prefer different activities and developing math and science skills at different rates, whereas Eliot (2009) argues against this perspective. Although Eliot does report that, on the whole, there are innate differences between boys and girls, she emphasizes that gender gaps arise due to an interplay between nature and nurture that changes the brain and people's biology through a process called plasticity.

Instead of highlighting biology, other researchers primarily emphasize sociocultural factors as affecting the different outcomes experienced by boys and girls in science. Shepardson and Pizzini (1992) reported that elementary teachers treated boys and girls differently in science class, in ways that might have communicated negative messages to female students, because the teachers believed boys possessed greater cognitive intellectual skills. Still other people emphasize that women are less engaged in science and less likely to succeed because science is viewed as masculine. They argue that this perception is constructed and reinforced because more men tend to study science, teach it, and are recognized as contributing to it. Similarly, they argue that science classes often treat science as impersonal, free of feelings, and competitive, which are stereotypically masculine characteristics (Eisenhart et al., 1996; Kahle & Meece, 1994; Kelly, 1985).

These characteristics are often associated with the 'nature of science', or epistemological views of science, supported by some people, curriculum materials, and activities in science classrooms. The nature of science that gets endorsed in class can influence individuals' comments regarding the goals of science, the role of experimentation, how scientific ideas change over time, and what qualifies as valued knowledge (Sandoval, 2003; Smith et al., 2000; Stanley & Brickhouse, 2000). By associating masculine characteristics with (school) science, curricular materials, classroom activities, and actions taken by teachers and students often construct and maintain a 'masculine nature of science' that can be unwelcoming to many females (Bianchini et al., 2002). For example, some people claim that the nature of science, specifically Western modern science, marginalizes women and other oppressed peoples by endorsing the belief that scientists are dispassionate, unbiased experimenters who discover the truth about nature, without acknowledging the passion, politics, prejudices, and invention involved in science (Hodson, 1999; Sowell, 2004).

The nature of science, sociocultural factors, and biology could impact the sex differences reported in science to varying degrees and some proponents of single-sex education claim that sex-segregated environments could provide means to alter these outcomes (Ainley & Daly, 2002; Rowe, 1988; Stables, 1990). For example, Rowe (1988) explained that single-sex settings might lead girls to develop greater confidence in their abilities in mathematics and science, leading to more positive outcomes in terms of their achievement in these disciplines. Similarly, Stables (1990) claimed that single-sex environments might contain less social pressure on girls to choose courses that are non-traditional for their sex, such as science and mathematics.

Other writers have argued that single-sex policies and settings can essentialize masculinity and femininity, thereby placing unnecessary constraints on students, and reinforce gender-role differences based on false sex and gender dichotomies (Cohen, 2009; Jackson, 2010). As a result, teachers, students and schools might knowingly or unknowingly act in ways that develop, maintain or exacerbate stereotypical sex differences, possibly assisting in producing the outcome that boys outperform girls in science or are advantaged in some ways. What does research of single-sex science classrooms suggest?

Research Studies Investigating Single-Sex Science and Math Education

Given that single-sex academic offerings are relatively new in public schools in the United States, there is limited research of these environments. Instead, much research cited in debates surrounding these settings has focused on studies from other countries or in private or religious schools. Although international studies are valuable to these discussions, people should be wary of generalizing the results to the United States context. For example, many countries have longer histories with public single-sex schooling than the United States, leading people in these countries, such as the United Kingdom and Australia, to be more comfortable and accepting of public single-sex education (Arms, 2007; Younger & Warrington, 2007). Therefore, results reported from these schools might differ from those that would be expected in public schools in the United States (Tyack & Hansot, 1990; U.S. Department of Education, 2005).

Similar arguments can be made regarding results from studies of private and religious schools in the United States, but the following review includes such studies because people have publicly supported expanding public single-sex offerings in the United States, including then-U.S. Secretary of Education Margaret Spellings, on the grounds that these changes would allow more families to have the choice of educating their children in sex-segregated learning environments, which had previously been isolated to select private and religious schools in the United States (Bracey, 2006; U.S. Department of Education, 2006b). Although this study focused on science, several of these earlier studies examined both science and mathematics, often because both disciplines serve as gateways to various careers and higher-paying jobs and because different outcomes for male and female students have been reported in both disciplines (Freeman, 2004).

Wood and Brown (1997) reported that girls who completed a single-sex algebra class instead of a co-educational one were no more likely to take advanced math and science classes but did experience a larger increase in their standardized test scores. Their results suggest that the single-sex classes might have benefited the girls' academic performance without increasing the girls' enrollment in additional math and science classes. Streitmatter (1997) focused on attitudinal changes that might arise from students' enrollment in single-sex mathematics and science offerings and reported that as a result of being in a single-sex class girls were more inclined to ask and answer questions and expressed greater confidence in their math abilities. Streitmatter (1998) performed a similar ethnographic study of two physics classes – one all-girl and one co-ed – taught by the same teacher in a public co-educational high school and reported that girls in the single-sex class had enhanced perceptions of themselves as competent science learners and appreciated receiving all of the teacher's attention.

In her 1999 book, *For Girls Only: Making a Case for Single-sex Schooling*, Streitmatter endorsed single-sex education for girls largely because of these attitudinal benefits. Although her review of quantitative studies measuring students' achievement led her to conclude that the results were contradictory and inconclusive, she claimed that these settings were valuable and worth supporting because her studies indicated that female students were more focused on their academic studies and expressed more positive attitudes towards math and science in all-girl settings.

Unlike Streitmatter, Baker (2002) argued that enhanced attitudes were *not* sufficient to claim that single-sex classrooms were good for girls. Baker sought to increase girls' participation in science courses and careers and wrote that 'affective improvements alone will not increase the number of girls who choose science and mathematics...A high level of mastery of the material is also needed' (p. 19). She studied single-sex middle school science and mathematics classrooms, and although the girls earned higher grades than the boys in these classes, the teachers acknowledged that the girls' grades were not much different than the grades they had received in their previous co-educational classes. Baker concluded that the single-sex environment seemingly did not impact the girls' grades, but might have contributed to girls' reported feelings of empowerment and positive self-concept.

Another single-sex study with a mathematics focus was Steinback and Gwizdala's (1995) investigation of students who attended two single-sex (one all-boy and one all-girl) Catholic schools that subsequently merged. Steinback and Gwizdala focused on the students' reported attitudes towards mathematics, specifically their self-confidence with the discipline and views regarding its usefulness, and analyzed the responses of female students the years immediately before and after the merger. They explored if the girls' attitudes changed within the first year of the merger and compared responses of female students from year two with those of male students from year two to see if their responses differed significantly. Overall, the female students' attitudes remained positive and fairly unchanged after the merger, and a significantly greater percent of male students reported being good at mathematics and that the subject was useful to them. Therefore, Steinbeck and Gwizdala concluded that the girls' attitudes did not significantly decrease as a result of being in classes with boys, but that more work was needed to find ways to enhance female students' confidence in their abilities and perception of the usefulness of mathematics.

Although the above studies do not constitute an exhaustive review of all reports on single-sex science and math courses in the United States, they are sufficient to provide insight into the outcomes that have been reported. They highlight the inconsistent results associated with single-sex science and mathematics classes at the secondary level. One common thread throughout the studies is that the researchers primarily focused on girls, possibly suggesting a greater interest in and attention to their outcomes. For example, Steinbeck and Gwizdala (1995) focused on how the merger of these schools impacted the female students and did not concentrate on how it affected the male students. As Mael (1998) wrote, 'the overwhelming preponderance of research [of single-sex education] has focused on females and female concerns' (p. 117). In my opinion, studies exploring single-sex education, or any studies that explore outcomes for boys *or* girls, have implications for both boys *and* girls. The following sections explain more about the particular participants in my study and the methods and perspectives applied to examine boys' and girls' experiences in this setting.

PARTICIPANTS AND METHODS

This study took place during the 2007-2008 school year and focused on a co-educational public middle school serving grades six, seven, and eight, which mainly consisted of students who were 11-13 years old, that allowed one team of seventh-grade teachers to separate their students into one all-boy class and one all-girl class. The school had done well academically, consistently meeting Adequate Yearly Progress (AYP) targets[2], except for the 'special education' subgroup, which did not meet AYP in English Language Arts in 2003, 2004, and 2006. Due to scheduling issues, no 'special education' student was able to be in the single-gender classes at the school. Although the principal said she did not want only a specific subset of students to be placed into this team and that the school had a computer 'randomly' assign students to it, she clarified that certain students could not be part of that team due to scheduling issues. Specifically, students who were enrolled in 'advanced mathematics', were labeled as having 'special needs', or were English as a Second Language (ESL) students could not be part of the single-gender team.

School administrative records indicated that at the start of the school year the school had 941 students (47.6% female), 220 (23.4%) of whom qualified for free, or reduced fee, lunches. Racially, the student body was less diverse, with 827 (87.9%) listed as White. Similarly, the faculty was predominantly female and White. Of the 38 faculty members teaching the core classes, 32 (84.2%) were female and 34 (89.5%) were White. As for the two single-gender classes, the girls' class started the year with 30 students, three (10.0%) of whom were students of color, and the boys' class started with 32 students, six (18.8%) of whom were students of color. All three female students of color were Black, while four boys were Black, one was Hispanic, and one was Asian/Pacific Islander. The remainder of the students were identified as White, much like the school as a whole. Overall, approximately 20% of the original 62 students in this single-gender team qualified for free, or reduced fee, lunches, which is roughly comparable to the student body as a whole.

According to interviews with the current principal and one teacher who started the single-gender program there, the program began in the 2000-2001 school year, after the principal at that time agreed to allow one team of seventh-grade teachers to separate their students into all-boy and all-girl classes. These teachers believed such classes would lessen the amount of sexual talk and interactions that occurred in class, which they felt was inappropriate for such young students and detracted from students' focus on academic study. Additionally, these teachers later became aware of information that highlighted brain differences between boys and girls that was used to argue that each sex could do better in school if distinct pedagogical approaches were used to best fit the unique male or female brain (see Glasser, 2008 for more information about the reasons these classes arose). The teachers only had anecdotal data of the team's effectiveness, but this offering continued because the teachers preferred the single-gender classes and the principal allowed them to continue. This was the only single-gender team in the school at the time of the study.

Shortly after the first day of the school year, the science teacher was hospitalized and Mrs. Kinsey (a pseudonym, as are all proper names referring to participants in this text) became the long-term substitute for the year. Mrs. Kinsey had completed her teacher training program the previous year and was extremely dedicated to doing well, as evidenced by the time she placed into calling parents, talking with colleagues about concerns she had with students and lessons, and meeting with students during lunch or other periods to assist them with assignments. She spent much time getting acquainted with the curriculum, materials and activities for her courses. She had no experience teaching single-gender classes and experienced no training in ways to lead all-boy or all-girl classes.

I engaged in an ethnographic study of these all-boy and all-girl science classes and made use of field notes; audio-taped and video-taped classes; students' work and classroom artifacts; and interviews with teachers, students, and an administrator. I was present for almost every science class during the first one-fourth of the academic year, missing only three class meetings this marking quarter after the original science teacher became ill, in order to allow the new teacher to develop greater comfort with her students and position.

To explore whether the two classes were learning the same science, I employed two approaches. One involved the purposeful collection of student grades as a traditional means of discussing student learning and I also applied a grounded theory methodology to the data that were generated on site to examine various themes that emerged. This approach was appropriate given that I did not enter the study or site with preset expectations regarding what I would experience and I wished to allow many codings to develop as a result of my experiences (Corbin & Strauss, 1990; Strauss & Corbin, 1994). As a result, I used a constant comparative method to code and analyze data and developed an initial coding framework that investigated classroom experiences – clustering the data broadly around emerging themes such as 'pedagogical approaches', 'student-student interactions', and 'teacher-and-student interactions' (Corbin & Strauss, 1990; Strauss & Corbin, 1994). For this paper, I primary focused on the developed second-and-third-level codes that concentrated on 'discursive approaches' and, ultimately, 'argumentation' in order to explore one specific element of the classes in more depth (see Glasser, 2008 for additional details about the larger study). Comparisons continued until a grounded theory emerged. More details about the coding and analyses will be described as necessary in the "Results" section below.

RESULTS

Grades
Overall, the all-girl and all-boy science classes received similar grades. Although Mrs. Kinsey had difficulty accessing the second quarter grades after they had been electronically submitted to the district, she provided performance data for the other three quarters. At the end of the first quarter the average grade in the girls' science class was 87% and the average grade in the boys' science class was 84% (with standard deviations of 10.78 and 7.67 respectively). In the third and fourth quarters, the difference between the classes lessened. During the third quarter, the girls averaged 89% and the boys 88% (with standard deviations of 6.36 and 7.90 respectively), while in the fourth quarter the girls averaged 83% and the boys 82% (with standard deviations of 6.96 and 8.32 respectively). The difference between the two classes each quarter was not significant at $p < 0.05$.

Although these data suggest that students in the two classes performed similarly, that need not mean the students learned the same things and were introduced to the same science. Teachers from this single-gender team commented about this idea of teaching the two classes the same content and claimed that the two classes were being taught similarly. One teacher said, "We have to teach the identical curriculum…And that's one of the ways we felt that we were really able to explain [the single-gender program] as a fair and equitable kind of a thing" and Mrs. Kinsey commented, "By separating the genders and teaching them the same thing…I can't say that I've necessarily taught 'em that differently." But were the lessons and experiences comparable? Using codes that emerged from my observations, this paper explores whether these classes had comparable experiences with argumentation. Before examining data, I will discuss why argumentation is important in science education, prior research that explored argumentation and science discourse – especially differences for boys and girls – and how argumentation is conceptually and operationally defined in this paper.

Argumentation
Many science classrooms are teacher-centered, dominated by didactic monologues from the teacher (Clark & Sampson, 2007; Sadler, 2006) and tightly-controlled discussions that follow a triadic pattern of teacher initiation, student response, and teacher evaluation (Goldman et al., 2002; Lemke, 1990). As a result, students have little opportunity to engage in discursive practices that are highly valued in science, including argumentation (Clark & Sampson, 2007; Duschl & Osborne, 2002; Kelly, 2007; Sadler, 2006). Argumentation is important in that it aligns with the National Science Education Standard stating that one goal for science education is to develop students who are able to 'engage intelligently in public discourse and debate about matters of scientific and technological concern' (National Research Council, 1996, p. 13).

More generally, argumentation is viewed as central to science because it plays a vital role in the social construction of scientific knowledge (Clark & Sampson, 2007; Driver et al., 2000). Over the last half century there has been a general shift away from seeing science as consisting of a series of facts or truths grounded in observation to a view that science is a social process of knowledge construction in which the acceptance of any claim relies more on the degree to which other people can be persuaded to accept the claim than on any inherent truth-value in the claim itself (Clark & Sampson, 2007; Driver et al., 2000). As a result, researchers argue that argumentation should be more strongly valued in science education and students should gain more experience 'talking science' and engaging in argumentation instead of being told information and explanations that they are expected to regurgitate on tests and during discussions (Clark & Sampson, 2007; Driver, et al., 2000; Lemke, 1990).

Although neither boys nor girls regularly get to engage in these discursive practices in science classes, researchers have reported that girls are often relegated to more silent, less active roles when group work or discussions do arise in school (American Association of University Women, 1992; Lee et al., 1994; Sadker et al., 2009). Kelly (2007) explained that within the field of science education, 'discourse-oriented studies of classroom interaction have only begun to examine the ways in which interactional patterns in science classrooms may be discriminatory to female students' (p. 456). However, among the studies that have examined these issues there has been consistent reporting that within co-educational classes female students had fewer interactions with their teachers during discussions and boys were privileged in terms of the quality and quantity of discursive experiences in these classes (Kelly, 2007; Scantlebury & Baker, 2007). For example, in a study by Kurth et al. (2002), the researchers reported that male students obtained more opportunities to practice narrative and paradigmatic forms of talk because they received more speaking turns. Similarly, Hsi and Hoadley (1997) reported that teachers often called on boys more than girls in science class, leading to gender inequitable participation. As a result, science classrooms have silenced female students, relative to male students, leading boys to have more opportunities to engage in valued discursive practices within that space (Hsi & Hoadley, 1997; Kelly, 2007).

But what exactly is argumentation, conceptually and operationally? Argumentation can have different meanings depending on the perspective employed. A cognitive perspective views argumentation as the articulation and expression of informal reasoning, whereas a sociocultural perspective posits that argumentation is not simply the expression of reasoning, where reasoning is the important process and argumentation is just a reporting mechanism (Sadler, 2006). Instead, this second perspective views argumentation as part of a social practice that is used to persuade other people of claims (Clark & Sampson, 2007). It refers to ways evidence is used in reasoning and assumes a fundamental position in the collective process of making meaning and affecting learning (Kelly, 2007; Sadler, 2006). This conceptual understanding of argumentation was applied to the current study and argumentation was operationally defined as a discursive event involving a *challenge* and a *defense*, with two or more participants, at least one of whom was Mrs. Kinsey. A challenge was operationally defined as any verbal claim that opposed another voiced perspective, while a defense involved the invoking of utterances to support the initial or opposing claim. (*Claims* here are defined similarly to how Toulmin (1958) defined them, referring to any conclusions whose merits must be established.) These defenses need not invoke scientifically correct information, but could be used by a participant as justification for arguing that a claim was true or false. These two behaviors, challenge and defense, needed to occur in the same exchange in order to be coded as an *instance of argumentation*.

For this paper, I analyzed lessons from weeks in which I videotaped classes because these recordings provided me with a great deal of data (e.g., field notes, audio data and video data) that enabled me to review more of the classroom happenings and strengthen claims. During the academic quarter when I was present, I received approval to videotape lessons for six weeks and I examined one day of science from each one of these six successive weeks. Over these six weeks, each class had 16 science sessions and the analyzed lessons were ones in which students engaged in an array of activities, including laboratory work, individual work done at their seats and whole-class discussions. I omitted the three lessons where students spent part of the period completing tests or quizzes, and chose lessons that I thought would involve much discussion. Due to variations in the amount of time devoted to science on any given day (either one or two periods), and to periods being shortened some weeks due to standardized testing, the length of each lesson was not identical, and I ultimately analyzed over seven hours of lessons from each class.

In order to code consistently, the operational definitions mentioned above were applied to all analyzed lessons. Likewise, several additional decisions were made:

- I only coded discursive events that transpired during whole-class discussions because exchanges that took place among groups of students might have been observed in one class due to a group's proximity to either myself or data collection equipment, but not noted in the other class because the exchange took place farther away. Additionally, whole-class discussions were assumed to be heard by all members of the class and were implicitly validated as legitimated ways to talk in science class.
- I only coded discursive events in which Mrs. Kinsey was a participant in the conversation. This decision was made, in part, for the same reasons discussed above. I did not wish to code 'side conversations' that I could hear in one class because of where specific students were seated relative to me or data collection equipment without being able to code similar conversations that took place in that class or in the other class. Additionally, I felt it was important to focus on events that contained Mrs. Kinsey because these events would be instances when the acts of challenging and defending were implicitly or explicitly endorsed by the dominant authority figure in the room.
- To be coded as an instance of argumentation, the challenge and defense must focus on science content. For example, when Mrs. Kinsey told the girls they would resume their regular class schedule the following week because they would be done with state tests, some girls challenged her by saying that the testing schedule would remain in place since sixth and eighth graders would still be taking tests. Although this exchange involved a challenge and defense, my analyses focused on instances of argumentation around science content.

Table 1 records the number of instances of argumentation that were noted in the analyzed days of science, as well as titles I created that summarized the focus of each lesson. In total, the boys' class contained more than three times as many instances of argumentation (22 compared with 7) over these six days. On five of the six days, the boys engaged in more argumentation than the girls, and the two classes contained the same number of instances of argumentation on the sixth day. Although the data suggest that neither the boys nor the girls engaged in much argumentation (i.e., the boys averaged approximately three instances of argumentation each hour of science while the girls averaged approximately one instance of argumentation each hour of science), the boys were granted greater exposure to argumentation and the practice of challenging and defending claims. I will provide excerpts below as examples that clarify the terms and highlight the differences between the two classes.

Table 1. Number of Instances of Argumentation During Different Science Lessons

Day	**Title Given to the Lesson**	**Instances of Argumentation in:**	
		All-boy class	**All-girl class**
Sept. 28	Five Characteristics of Living Things	8	2
Oct. 2	Blob Activity and Notes on Organelles	3	1
Oct. 9	"Identi-Cell" Activity	2	0
Oct. 19	Organelles under a Scope and Quiz Review	2	2
Oct. 26	Lab Roles and Notes on Osmosis and Diffusion	3	1
Oct. 30	Energy Waste Activity and Report	4	1
Total		22	7

Excerpts.

At the start of the unit on cells, Mrs. Kinsey introduced the 'five characteristics of living things'. Before displaying these characteristics for students to record, students compiled their own lists of 'what a living thing needs to be considered living'. In each class students stated items they recorded. Below are excerpts from analogous portions of the activity in the two classes followed by a discussion of the instances of argumentation that transpired in each class during this time. Since the boys' class met earlier in the day than the girls, and Mrs. Kinsey might have modified the girls' lesson as a result of her experiences with the boys, I will present events from the boys' class first.

The all-boy class:

Mrs. K: Alright. Raise your hand and tell me one of the things you guys put that to be alive you need. (*Several students raise their hands)* Allen.

Allen: Well, oxygen, I mean a heart sort of.

Mitch (*without being called on*): Trees don't have hearts.

Allen: Yeah they do. In stories.

Mrs. K: I want him to list something that is needed. Don't tell him he's 'right' or 'wrong'. It's not your job.

Allen: Wouldn't they need a heart? To circulate blood and stuff?

Mrs. K: I guess, as in the words of Mitch, "Do trees have hearts?"

Allen: No.

Steven: Yeah. They do.

Mrs. K: Okay? So think about it. Jason.

Jason: Oxygen.

Mrs. K: Oxygen. (*To Allen*:) I'm not saying you're wrong, I'm just saying to ask that question, "Do trees have hearts?"…David.

David: Shelter.

Mrs. K: Shelter.

Mitch: Tress don't have shelter.

Another student: You don't need shelter to live.

Student: Yeah you do. (*Echoed by a few others*)

Brian: Trees have bark (*Class gets louder as boys discuss different contributions*)…

Mrs. K: Boys I'll wait…Steven.

Steven: Tissue.

Mrs. K: Tissue.

Brian: I didn't think; Do trees have tissue?

Steven: Yeah. Bark.

Mrs. K: Alright. Actually yes, they do.

The all-girl class:

Mrs. K: Alright girls. Raise your hand and give me one thing on your list. (*Several students raise their hands*) Julie.

Julie: A pulse.

Mrs. K: A pulse.

Dana (*without being called on*): A brain.

Mrs. K: A brain.

Abby (*without being called on*): Veins. Cells.

Another student (*without being called on*): Water.

(*Other girls state things from their lists without being called on*.)

Mrs. K: Whoa! Wait. Stop. Raise your hand. Abby you said?

Abby: Veins and —

Mrs. K: —veins. Tanisha.

Abby: —and cells.

Tanisha: Cells.

Mrs. K: Cells. Mary.

Mary: Reproductive system.

Mrs. K: Reproductive system. Susan.

Susan: Um (*pauses*), core.

Mrs. K: Core?

Susan: Core.

Mrs. K: A core. Okay.

In the boys' class, Mitch challenged Allen's response that all living things need hearts by saying, "Trees don't have hearts". Mitch's statement implicitly endorsed a view that trees are living and he challenged the claim that all living things needed hearts by claiming that some living things, such as trees, did not have hearts. Allen defended his initial claim (albeit questioningly) by saying, "Wouldn't they need a heart? To circulate blood and stuff?". This exchange was coded as an instance of argumentation since Allen explained his reason for saying "heart" by suggesting that a heart would be necessary for living things, including trees, to circulate blood. Although Mitch was reprimanded for evaluating a peer's response, his comment was validated when Mrs. Kinsey used his idea and credited him by saying, "As in the words of Mitch, 'Do trees have hearts?'" As additional responses were supplied, students and Mrs. Kinsey continued to use this analytic tool to inspect other contributions. After David said that things needed "shelter" to be alive, Mitch challenged that by saying "Trees don't have shelter" and another classmate challenged David's response by saying "You don't need shelter to live." Several students replied that trees do need shelter, with Brian defending this perspective by explaining that "trees have bark," implicitly communicating that bark is trees' shelter. This coupling of another challenge with a defense was coded as another instance of argumentation. Additionally, when Brian used the "Do trees have [item]" question to challenge whether "tissue" should be on the list, Mrs. Kinsey responded "Yes", that trees do have tissue, and Steven explained his view that "bark" constituted tissue for trees. This challenge and defense was a third instance of argumentation seen in the excerpt from the boys' class. As seen in these exchanges, the boys challenged and defended different claims and Mrs. Kinsey joined in these exchanges.

While the boys engaged in these instances of argumentation, the girls were seen to list items without any ensuing discussion surrounding their contributions. Their discussion remained in a traditional triadic pattern in which Mrs. Kinsey initiated the exchange, a student was expected to provide one response, and the teacher evaluated it through repeating and acknowledging the contribution. Although she told the boys their job was not to evaluate whether responses were 'right' or 'wrong', they ended up challenging multiple responses. With the girls, as with the boys, it seemed as though Mrs. Kinsey wanted only one student to speak at a time and limited contributions by having students state "one thing" from their lists. These wants seemed similar in both classes and she positioned herself as the primary evaluator who directed students' participation through selecting when and who gained access to the official classroom discourse space. As a result, she tightly controlled the discussion and kept it teacher centered. Although students in both classes did not get many opportunities to engage in argumentation, the above example highlights that boys had more experience engaging in, and even observing, argumentation than the girls. *Table 1* indicates that this difference was not isolated to this one vignette and such a difference suggests that these classes were being exposed to different ways of doing science through different experiences with argumentation.

Additional excerpts can be used to highlight more examples where instances of argumentation transpired in the boys' class and also to show how such opportunities were not pursued in the girls' class. I am unable to provide data and examples of an absence of something (i.e., an absence of instances of argumentation in the girls' class) but the overall results were that while both classes experienced relatively few instances of argumentation the boys experienced many more opportunities to witness and participate in such discursive practices. The excerpts below are from analogous portions of the lesson after Mrs. Kinsey finished asking students to contribute responses to the list of things needed for something to be considered living. She had them then flip over the data sheet they used the previous day to record notes on the back of this sheet, which was titled 'Five Characteristics of Living Things'. She presented the characteristics one-at-a-time using an overhead projector and students were to record the 'correct' answers for 'what a living thing needs to be considered living'. Below are excerpts from each classroom just before, and as, Mrs. Kinsey introduces the first of five characteristics of living things:

The all-boy class:

Mrs. K: In order to be alive, you need to have these five life functions...For example, number one, it needs to grow. Something grows…

Rick: Shouldn't Tommy be dead then? On *Rugrats*? He doesn't grow.

Mrs. K: He obviously had to grow some.

Rick: Well he didn't. Cause, like, the episodes were made from '96 to, like, 2003 and he never grew.

Mrs. K: He's a cartoon. (*Several students start talking about Rick's comment. The volume increases.*) Boys! Write it down!

The all-girl class:

Mrs. K: Is a tree a living thing?

Some students: No.

Some students: Yes.

Mrs. K: Ooo. I heard a couple people say "no"…

Julie: They had in a book that rocks were living too.

Linda: They breathe.

Dana: Rocks don't breathe silly!

Mrs. K: Alright...Okay. Trees are living things. If you take a look up here at this, these are; I want you to open up your course pack. On the back of your data table from yesterday, you're gonna see where it says, 'Five Functions of Living Things'....The first one that you need to be considered a living thing is you need to be able to grow. Something grows. Okay?...

Michelle: Do we have to write this down?

Mrs. K: Yeah.

As seen in the initial excerpts presented before, earlier in the lesson the boys' class discussed trees as living things and now this part of the lesson contained related dialogue in the girls' class. The girls had science after the boys and Mrs. Kinsey might have found the boys' comments regarding trees valuable. As opposed to its use in the boys' class, these comments were not introduced when girls presented items from their lists, as a means to evaluate responses and defend claims. While the boys' class seemed to implicitly agree that trees were living and they used that assumption to argue whether or not specific characteristics were needed for something to be alive, this 'tree topic' was introduced as a 'yes/no' question within the girls' class and these students were not challenged to explain or defend a position. Although Mrs. Kinsey asked the girls if they thought a tree was a living thing – and some students responded that it was while other students said it was not – she ultimately stated for the girls that "trees are living things," without defending this claim. The topic of trees in this class did not noticeably advance the conversation concerning characteristics of living things and did not lead to, or was not used as, an opportunity to engage in instances of argumentation. While this portion of the lesson contained instances where girls disagreed with others' responses, thereby 'challenging' claims, there were no accompanying 'defenses'. For example, when some girls said "no [a tree is not a living thing]" some students responded "yes [a tree is a living thing]" but no student in this class defended her comment by providing support for her stated claim. Similarly, Dana challenged Linda's comment that rocks breathe by saying "Rocks don't breathe silly!" but since neither she nor Linda provided a reason for her perspective, no defense was enacted and this exchange was not coded as an instance of argumentation.

Conversely, in the boys' class when Mrs. Kinsey said that in order for something to be alive it needs to grow one of the boys challenged this statement. Rick's comment implied a view, whether serious or not, that an animated television character, Tommy, did not grow but was indeed alive. His comment was a challenge to the view that in order to be alive something must grow. Mrs. Kinsey herself defended the position that living things need to grow, initially using circular logic to reason that "he [Tommy] obviously had to grow some" presumably because if he were alive he had to grow and meet all the characteristics needed to be alive. When Rick again challenged the comment by stating that the character never grew during the seven years when episodes were made, Mrs. Kinsey defended the characteristics of living things by stating that this character, Tommy, is a cartoon, therefore implying that he can be exempt from meeting all the characteristics of living things because he is not alive. Subsequently, other boys in the class began debating this issue. When the boys were introduced to this first characteristic needed for something to be alive the class was exposed to argumentation, whereas when the girls were introduced to this first characteristic they simply recorded the characteristic and did not argue and were not encouraged to engage in argumentation. Overall, when the boys expressed disagreement and 'challenged' responses, they were more likely to 'defend' their claim and provide evidence that countered the initial claim (e.g., "Shouldn't Tommy be dead then?...He doesn't grow."), whereas the girls were only seen to make opposing claims without supplying evidence (e.g., "Rocks don't breathe silly!").

DISCUSSION

The two classes progressed through similar lessons and received similar grades, but the events during these analyzed lessons differed noticeably with regard to argumentation. In agreement with prior research studies, both science classes were fairly typical in that the classes were teacher-centered with few opportunities to engage in argumentation (Clark & Sampson, 2007; Duschl & Osborne, 2002; Kelly, 2007; Sadler, 2006). Among the discursive interactions analyzed, the boys and girls were seen to be exposed to inequitable discursive experiences, as also reported in co-educational classrooms (Hsi & Hoadley, 1997; Kelly, 2007; Kurth et al., 2002); however, unlike in co-educational classrooms, both boys and girls did not get to witness similar discursive practices since they were in separate classes. In this study, the boys exhibited a greater likelihood to engage in argumentation, which could grant them greater opportunities and comfort with a skill that is valued within scientific communities, possibly better preparing them to pursue future science opportunities. Therefore, the differences noted here might lead to results similar to those reported by Wood and Brown (1997) who noted that girls who took single-sex math classes were not any more likely to take additional math and science classes.

The theory emerging from this study is that single-sex settings can construct differences between the sexes by giving them different experiences in classrooms. Although differences between boys and girls can be constructed in co-educational classrooms, single-sex settings provide a structure that is amenable to providing boys and girls with different academic experiences since they are physically separated from one another. Even when other factors – including that boys and girls received similar grades, had the same teacher, and ultimately saw the same overhead slides (e.g., the same slides relating to the 'five characteristics of living things') – could suggest that the sexes are separated *and* equal, this investigation highlighted that some differences might arise through this separation that could impact their future courses and careers.

One limitation of this study is that it focused on one part of one school year. Participants' discursive behaviors might have changed as the year progressed after they had more experiences in, and possibly became more (un)comfortable with, these environments. Additionally, a more longitudinal study would enable stronger claims to be made regarding possible connections between what transpired in these classes and the students' future experiences, especially their interest and performance in additional science classes. At present, connections between how and if these discursive differences impacted the students' futures are unclear but the differences did arise, raising concerns about their potential impact and highlighting the importance of exploring these single-sex settings in more detail.

Another limitation was the lack of data from a co-educational classroom to see how the boys and girls in such a class engaged in argumentation. Although I initially hoped to focus on one all-boy, one all-girl, and one co-ed class, I was unable to locate a geographically-convenient public school that contained such an arrangement. The school in this study had co-ed science classrooms in the seventh grade, but these were excluded from this research because they were taught by different teachers than those leading the single-sex classes and would have introduced additional variables into the design that would have lessened the rigor of the study. Additionally, scheduling difficulties at the school made it impossible for me to consistently observe both the co-educational and single-sex science classes. Nevertheless, studies that investigate aspects of single-sex and co-educational environments at the same school could contribute much to this field. While this study focused on single-sex classes in a co-educational school, additional studies should also explore public single-sex schools and see if results from such settings are comparable to results from single-sex classrooms in co-educational schools.

CONCLUSION

To situate this study's importance in the broader education community, it is valuable to restate that people have concluded previously that there is little evidence to strongly support endorsing single-sex programs over co-educational ones (Arms, 2007; Mael, 1998; Salomone, 2006; U.S. Department of Education, 2005). While many of these writings noted the dearth of quality research that has examined these environments, other people claimed that single-sex settings could lead to a closing of gender gaps in science performance and interest (Ainley & Daly, 2002; Rowe, 1988; Stables, 1990). This work is one of a very small set of research studies that has investigated these offerings, especially in middle school science classrooms where such sex differences are often first observed or grow more dramatic, and it compared the experiences of boys and girls instead of solely focusing on members of one sex. Additionally, while some studies have reported that boys and girls have inequitable discursive experiences in science classrooms that privilege boys (e.g., Hsi & Hoadley, 1997; Kurth et al., 2002), there is still limited research exploring discourse patterns in science education and this is especially true within single-sex classrooms in the United States (Kelly, 2007). Although the study focused on data from one school in one part of the school year, it does highlight different experiences for boys and girls and raises concerns about these settings, encouraging future studies to pursue these topics further.

Even when the all-boy class and all-girl class could be argued as being similar to each other because they had access to the same teacher and instructional materials, the classes might receive unequal learning experiences. In this setting, the boys were advantaged by gaining greater exposure to argumentation. The results and theory arising from this research do not suggest that single-sex settings are inherently structured to disadvantage girls and women in science; instead, the theory posits that these sex-segregated settings could disadvantage boys as these settings are amenable to endorsing and advancing differences between boys and girls. This study highlights the concern that the amended federal regulations, and the subsequent rush to provide more single-sex offerings in the United States, could impact equity goals and gender-related outcomes in subtle, or even more noticeable, ways. Single-sex offerings have the potential to impact many student outcomes and more research is needed of these offerings.

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ENDNOTES

[1] Poor and inconsistent definitions of sex and gender commonly used in education research (Glasser & Smith, 2008) leave room for arguments that "single-sex," "single-gender," or neither would be most appropriate when referring to these classes. Given this reality and my own personal perspective, I am unable and unwilling to apply the terms consistently. When relevant, I use the terms supplied by participants in an effort to best respect their voices.

When discussing my analyses, I intentionally switch terms to show the arbitrariness of their application and disrupt the boundaries that get reified through consistent use of the same term(s).

[2] The Federal No Child Left Behind (NCLB) Act of 2001 required each state in the United States to develop plans and means of assessing students' performance in meeting academic standards based on results from standardized tests. Adequate Yearly Progress (AYP) is defined by each state as a way to measure a school and district's performance and a way to evaluate the percentage growth in performance achieved by each district and subgroups of students within a district or state. Each state was required to establish a timeline for Adequate Yearly Progress so that within 12 years after the 2001-2002 school year all students in various subgroups specified in NCLB would meet or exceed the state's standards.

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