

(Dis)Interest in Science: How Perceptions About Grades May Be Discouraging Girls

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Abstract

In spite of advances in many fields, women are still under-represented in the sciences. In this paper, we report the results of a study investigating the perceptions of high school girls enrolled in science classes on whether hard work leads to success, if they are receiving the scores they deserve, and if the assessment system used in class is unfair. Analyses indicated that girls received better grades than boys, but generally believed that hard work does not lead to success and that the grading system is not completely fair. The findings suggest subtle ways that classrooms may be discouraging girls, and recommendations for teaching practices in science education to address this problem are provided.

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Introduction

The national spotlight again shines on the dwindling number of students entering the sciences as a profession, with international reports highlighting our lost standing in world rankings (OECD, 2003) and the popular press reporting the poor achievement of students in science classes (Lemonick, 2006; Science Scores, 2006 author unknown). Further, studies indicate that the large gender differences between the number of women and men entering the sciences have not receded. Girls continue to lose interest and abandon plans for careers in the field at a higher rate than boys (Kerr & Robinson Kurpius, 2004), and college females continue to opt for majors in science and mathematics at a lower rate than college males (National Center for Education Statistics, 2000). Women are still less likely to be employed in sciences than men, and for those women who are employed in the sciences, they earn, on average, 20% less than their male counterparts employed in the same job (Graham & Smith, 2005). If our nation needs more scientists, this under-representation of women must be examined and remediated, and it starts with girls in school.

Why are girls less likely to pursue careers in the sciences? The enduring under-representation of women in science has plagued educators for many years, despite concerted efforts to raise girls' academic success and interest in the field, such as mentoring programs (McLaughlin, 2005), and single sex classes (Ransome, 1993). There

is clear evidence that girls have virtually closed the previous achievement gap in science. In all fields, except physics, the extant literature shows that girls achieve academically at the same or higher levels than their male counterparts (Kleinfeld, 1999; National Center for Education Statistics, 1997; National Science Foundation, 1996). The answer to why fewer girls pursue science, therefore, does not seem to lie in underachievement.

Nor does the answer appear to lie in lack of access to science instruction. Title IX of the 1972 Education Amendments prohibits gender discrimination in all school programs, and since the early eighties, schools across the country have taken pro-active steps to overcome the representation gap in math and science with programs designed to encourage girls' enrollment in these disciplines (Gilbert, 2001; Sandler, Silverberg, & Hall 1996). Providing programs for girls, however, is just a small part of addressing the problem of under-representation of women in the sciences. Programs often do not address the beliefs that students, teachers, parents, or administrators bring to the learning environment – they just provide access opportunities for girls, with the belief that the access alone will produce the desire to pursue sciences. Although getting girls into science classes is important, many school programs fail to recognize or address some of the underlying assumptions about the place of women in the sciences (Gilbert, 2001).

Discriminatory treatment of females within science classrooms also does not explain the under-representation of women in sciences. For the most part, overt acts of sexism in the classroom have disappeared from our public schools and college campuses (Allan & Madden, 2003). However, even without blatant discrimination, girls may be treated differently than boys by science teachers (mostly males), who may interact differently with female students than they do with male students or who may not recognize that their teaching methods are not effectively reaching girls (Sandler, Silverberg, & Hall, 1996). Sandler, et al. (1996) noted that one way girls are treated differently in science classes is in the types of questions they are asked. For example, girls are often asked lower level factual questions which can be evaluated right or wrong and only permits specific instruction from the teacher. Whereas, boys are asked open-ended higher level questions which allows them to “display their talents,” engage in critical thinking, and even guess at the answer (p. 10). Several other examples of how girls are treated differently than boys include: grouping women in ways that indicate they have less ability or status; making seemingly helpful comments which imply girls are not as competent as boys; doubting girls work and accomplishments; expecting less of girls in the future; or calling males “men” and women “girls” (for a complete review see Sandler et al., 1996 pp. 10-11).

The question of under-representation of women and girls in science, therefore, must include an examination of the more subtle aspects of classroom climate. If schools just “check off” that they have provided science opportunities, that girls are achieving satisfactorily, and that there is no overt discriminatory treatment toward girls, it may obfuscate classroom practices that are contributing to a chilly climate for girls and young women in science. Chilly climates are defined as the “... subtle ways women are treated differently - ways that communicate to women that they are not quite first-class citizens in the academic community” (Sandler & Hall, 1986, p. 1). Chilly climates can be created by overt behaviors directed at girls to make them feel unwanted, such as not calling on them when they raise their hands or praising males but not females (Morris, 2003). On the other hand, they can be more covert, such as deliberately grading girls' work more

severely than boy's work. Or chilly climates can be created unintentionally, stemming from lack of knowledge or insensitivity to the different learning styles and needs of girls and boys (Salter, 2003).

Further, classroom climate is not defined solely by behaviors exhibited by others, but also by the perceptions girls hold about the learning environment. Believing that these perceptions can influence girls' motivation and participation in the class, we attempt to explore in this study a few of these subtleties by examining their perceptions on specific classroom practices. Although the literature indicates that girls are performing at equal or higher levels than boys, what is often not reported are more subtle factors that affect girls' efficacy in science, such as their perception of classroom grading practices. Specifically, this study is an effort to describe the perceptions high school girls have about the grading practices in their science classes.

Research Questions

The questions that guided this investigation are:

Question 1: Do students perceive that their hard work will lead to success in class?

Question 2: Do students perceive that they are accurately assessed?

Question 3: Do students perceive that the assessment system in class is unfair?

Methods

Participants

The participants for this study were 121 grade 10 and 11 high school students from a medium sized high school located outside Montreal, Canada. This included 46 females and 75 males, ranging in age from 14 to 18, with an average age of 15.72 years. The age range is due to the October data collection, which meant students with later birthdays were still 14 in 10th grade, and students with early birthdays, or those who started a year later, had turned 18 in the 11th grade. Students represent varied achievement levels, SES, cultures, and ethnicities. The breakdown of gender by grade indicates that 33 girls were enrolled in grade 10 and 13 in grade 11. The breakdown for boys indicates that 47 were enrolled in grade 10 and 28 in grade 11. Permission from the teacher, school, school board, and parents was obtained before administering the surveys. Additionally, we obtained informed consent from each student, and they were told that they could stop at any time or have any of their responses eliminated from the analysis.

All of the students had the same teacher during the school year being studied, although they entered the class with a wide variety of experiences with multiple teachers in previous years. The teacher is a male, award-winning science teacher with 17 years of teaching science experience and a Master's degree in his field. He received two district awards for outstanding teaching and his dedication to his profession. We limited the study to the students of one teacher, to provide greater power in interpreting the results, since by doing so, we did not have to disentangle teacher effects from the student responses. The teacher's instructional approach included a mixture of direct instruction,

cooperative groupings (Abrami, et al., 1995), and lab work. At the start of a unit the teacher would begin with direct instruction and then move to cooperatively structured groups for lab work. Within the groups, students took on various roles (e.g., experimenter, recorder, materials coordinator), which they alternated after each experiment.

Measures

The Classroom Life Scale (CLS; Johnson, Johnson, & Anderson, 1983) was used to measure attitudes toward grading. The CLS is a 5-point scale ranging from 1=Completely False to 5=Completely True. The CLS consists of several subscales measuring students' attitudes on the fairness of grading, grading practices, cooperativeness, feelings of alienation, academic self-esteem, academic support, goal and resource interdependence, external motivation, cohesion, independent learning, competitive learning, controversy, valuing homogeneity and heterogeneity. This paper is focused on the grading practices in terms of fairness of grading and the beliefs that one is getting the scores they deserve. On the CLS, students were encouraged to provide written feedback on any aspect of their learning in science courses. Comments were analyzed for any patterns or themes that related to the study's questions. Achievement data was also examined, consisting of two mid-term exams held in mid-October and mid-May and weekly lab assignments.

Procedure

In early October, researchers administered the CLS to all students in their science classroom. We told students that we were interested in learning about their attitudes toward science and how these attitudes affected their learning and grades. Students were informed that we wanted their honest responses to the questions and that there was no right or wrong answers. The teacher was not present during the survey administration and was not shown the completed questionnaires; he only saw aggregated data after the study was completed. The study lasted for seven months (October to May). In late May, two weeks after their midterm, the CLS was administered a second time. We decided to wait two weeks before administering the CLS so that any positive or negative emotions surrounding their mid-term results would have lessened, and thus would not overly influence their responses.

Throughout the year, students completed weekly assignments and were graded on all assignments. By the time the students completed the first mid-term exam they had completed five weekly assignments; by May they had completed more than 20. The exams and the weekly assignments were evaluated by the teacher and factored into their overall grade.

Results and Discussion

The results of the study are presented by research question. However, before examining the results of the survey, we analyzed students' grades on weekly lab assignments, plus two mid-term exams to highlight any gender differences in achievement. On average, girls carried a 'B' average and boys carried a 'B-' average in the class. The averages were submitted to a one-way analysis of variance (ANOVA) and

the test indicated that the differences were not significant $F(1,120) = .913, p > .34$. The perceptions of the students should be interpreted in light of the overall achievement levels in the class.

Research Question 1: Do students perceive that their hard work will lead to success in class?

Statistical evaluation of pretest scores measuring differences between girls and boys on their perceptions that hard work would lead to success in the course was performed using the Mann-Whitney U-Test. This nonparametric test was used because an ANOVA test of means did not meet the test of homogeneity of variance assumption necessary for using the parametric one way ANOVA. The results of the analysis showed that girls and boys likely entered the course with different perceptions about the value of hard work leading to success ($U = 1032, p < .001$, two-tailed). Was this gender difference in perception maintained throughout the course? To test this possibility we submitted posttest scores to a univariate ANOVA procedure. Tests of posttest score means showed that the assumption of homogeneity of variance underlying ANOVA was met and the results of this test indicated that girls and boys differed significantly on their perceptions that hard work would lead to success in the class $F(1,119) = 5.96, p < .01$, partial eta squared = .048; girls $M = 3.83, SD = 1.14$; boys $M = 4.29, SD = .94$.

To find out if differences in perceptions of hard work leading to success shifted from pretest to posttest within gender we conducted a correlated samples t-test separately for girls and boys. The results showed that girls exhibited a slight positive shift in overall mean scores in their perceptions from pretest to posttest (pretest $M = 3.52, SD = 1.16$; posttest $M = 3.83, SD = 1.14$); however, the change was not significant, $t(45) = -1.28, p > .20$. Likewise, for boys the results indicated that although there was slight downward shift in overall mean scores from pretest to posttest (pretest $M = 4.33, SD = .87$; posttest $M = 4.29, SD = .94$) the change was not significant $t(74) = .359, p > .70$. Although scores for both girls and boys were on the positive side of the scale, boys continued to agree with the statement that hard work would lead to success in class. Whereas, girls were closer to the midpoint of the scale which reflected the belief “sometimes true/sometimes false” indicating that girls were much more ambivalent about their beliefs in the value of hard work leading to success in these classes.

Discussion Question 1

It is clear from the data that girls entered the class with less confidence that their hard work would lead to success in science. We looked at the percentage of scores for girls and boys who chose “agree or strongly agree” and found that 50% of the entering girls agreed that hard work pays off, whereas 80% of the entering boys did. Even after the girls were in the class for almost a year with an award-winning teacher, their belief in the benefit of hard work in science did not change or approach the belief held by boys. Previous research and the qualitative data from the study provide insight into why girls may hold this belief. The pedagogy of independent and competitive learning inherent in science classes – lab experiments, forming hypotheses – has ramifications for girls that are linked to gender socialization and help explain why girls feel less sure about hard

work leading to success (Ball, 2002). For example, Fennema and Peterson (1985) found that classes that require autonomous learning behaviors favor boys because they have many more opportunities both inside and outside of school to practice these skills. Boys are often given more freedoms than girls, participate in more competitive play and activities, and are more socialized for independence. In a 1996 study, Silverman and Pritchard observed that when students were working independently and must wait for the teacher's time and attention, boys benefit because they are more outspoken in demanding attention. They observed that teachers often ignored interactions between boys and girls that are negatively affecting girls' perceptions of the class. For instance, they noticed that boys rushed to get the supplies they needed, overrunning the girls in the process.

Girls, therefore, may be receiving reinforcement of the stereotype that "boys are better in science" by observing and being victimized by boys' more aggressive approach to learning, and the teacher's tacit acceptance – even approval – of this behavior. This suggests, and other research supports it, that girls would perform better in science and math classes if the classes were taught in a cooperative or individualized format rather than a competitive format (Eccles et al., 1998; Meece, 2002; Meece & Eccles, 1993).

The comments from girls also support the premise that girls may not believe they are thriving in independent learning environments. For example, the perception of many of the girls in the class was that the teacher left them alone "to struggle." As one 15 year old girl in grade 10 stated, "*The teacher does not teach! He leaves us to our own devices. I suspect he wants us to fail.*" Another 15 year old girl in grade 10 shared a similar sentiment, but also referred to the teacher's willingness to answer questions "*Our teacher doesn't teach us enough. When we have a question he won't help us.*" And, a 17 year old girl in grade 11 stated "*The teacher should do some teaching. Not just answer your questions with another question. Also he should help you when you don't understand.*" Finally, one 16 year old girl in grade 11 stated "*The teacher shouldn't expect us to learn by ourselves because there are many times when I feel I cannot approach the teacher with a question because he will just ask me what I think, when I don't know [emphasis in the original] to start off with. It makes me feel dumb.*" It is noteworthy that none of the boys shared similar comments. Girls, therefore, seem more likely to interpret autonomous learning time as a teacher ignoring them or not caring if they fail. Their statements are also reflective of the socio-emotional warmth available to students in the classroom. Research in the area of socio-emotional warmth indicates that teachers who respect and care for students provide environments that facilitate student engagement, persistence on academic tasks, and the development of positive achievement-related perceptions (Goodenow, 1993; Midgley, 2002; Midgley, et al., 1989). The comments from girls suggest that girls do not feel accepted or confident enough to approach the teacher when they are experiencing difficulty, indicating a low level of socio-emotional warmth, which some would also call a "chilly climate." It should be noted that these are the girls' perceptions; researchers did not note any behavior that would suggest gender bias on the part of the teacher.. However, the fact the girls reported it is important, because people act on what they believe to be true (Bandura, 1997).

Research Question 2: Do students perceive that they are accurately assessed?

To answer this question, we conducted a univariate ANOVA on pre-and-posttest scores. On pretest, the test revealed a significant main effect for gender on perceptions of whether they are receiving the scores they deserve, $F(1,119) = 33.06$, $p < .001$, partial eta squared .217. The data showed that girls perceived that they were not receiving the scores they deserved in the class. Whereas, boys perceived that, for the most part, they were receiving the grades they deserved (girls $M = 2.63$, $SD = .951$; boys $M = 3.72$, $SD = 1.04$). On posttest, girls and boys did not differ significantly ($p > .99$) and they exhibited the same mean scores (girls $M = 3.11$, $SD = 1.14$; boys $M = 3.11$, $SD = 1.24$). Within subjects tests reflected a positive shift in perceptions for girls (girls pretest $M = 2.63$, $SD = .951$; posttest $M = 3.11$, $SD = 1.14$, $p < .02$). However, the scores were still very close to the midpoint of the scale reflecting “sometime true/sometimes false.” Boys, on the other hand indicated a significant negative shift on their perceptions of the accuracy of grading in the class (boys pretest $M = 3.72$, $SD = 1.04$; posttest $M = 3.11$, $SD = 1.24$, $p < .001$). Their responses also indicated greater neutrality in the accuracy of grading in the class. It’s important to note that the perceptions here refer to the particular grade a student was attaining and whether or not he/she believed it was fair. The third research question deals with whether or not students perceive the grading system used in the class as a whole is fair.

Discussion Question 2

The perceptions students hold are important, because a student’s agency, what he/she can and cannot control in the classroom, affects overall satisfaction in the course, and ultimately the subject. If boys are more consistently satisfied with the fairness of their science grades, they are more likely to continue study, resulting in a greater pool of potential students who might pursue this career path. Our data supports the premise that girls’ negative perceptions affect their decision to continue in science and take higher level courses. For example, the class breakdown for grade 10 during the year the study was conducted was 41.25% girls and 58.75% boys. In the following year, the 11th grade percentages were 31.70% girls and 68.30% boys, showing a much bigger drop in enrollment among girls.

Research Question 3: Do students perceive that the assessment system in class is unfair?

Entering perceptions on this question showed that gender significantly affected student perceptions of whether the assessment system in the class was unfair, $F(1,119) = 12.53$, $p < .001$, partial eta squared .095. The data showed that girls generally held the perception that the assessment system was not fair (girls $M = 3.76$, $SD = .82$). Whereas, their male counterparts in the class fell at the midpoint of the scale on whether the assessment system was fair or not (boys $M = 3.09$, $SD = 1.11$). However, the large standard deviation for males indicates greater variability in their responses on this question. On posttest, girls and boys did not differ significantly ($p > .63$) and they exhibited virtually the same mean scores (girls $M = 3.40$, $SD = 1.01$; boys $M = 3.40$, $SD = 1.12$).

To uncover whether there were differences in perceptions of fairness of grading within gender separate correlated samples t-tests were conducted for girls and boys. The

results indicated a significant change for girls on perceptions of the fairness of grading from pretest to posttest two-tailed significance $t(45) = -2.84, p < .007$ (pretest $M = 3.76, SD = .82$; posttest $M = 3.30, SD = 1.00$). Likewise, for boys the results indicated a significant change from pretest to posttest two-tailed significance $t(74) = -2.08, p < .04$ (pretest $M = 3.09, SD = 1.11$; posttest $M = 3.40, SD = 1.13$). Over the course of the academic year girls showed a positive shift from pretest to posttest. Still, the shift indicates that girls became more ambivalent about the fairness of the scoring system. Boys, on the other hand, moved in the opposite direction from girls indicating a greater negative belief in the overall scoring system used in the class. Even with the shifts toward the middle of the scale, a large disparity still existed between the girls' and boys' perceptions of grading fairness.

Discussion Question 3

Although girls were achieving higher than boys in their science classes, they had the perception that the grading system was unfair. Why these perceptions? Even with their posttest shift toward the midpoint of the scale, it is still troubling. The shift was just to the midpoint of the scale reflecting “sometimes true/sometimes false,” and this is hardly an endorsement about the fairness of grading.

Many studies point to the link between higher grades and student efficacy in the subject (Jinks & Morgan, 1996). For example, Bandura (1997) argues that students who achieve higher tend to display higher levels of self-efficacy, are more motivated, and show more interest in the subject. This study challenges that assumption for girls in science classes, or at least suggests that good grades may not be enough to affect their efficacy. In the case of these students, the girls were achieving at a higher rate, and even after a year with an outstanding teacher, did not believe the grading system was completely fair, suggesting that other, more subtle factors may have been in play that were negatively affecting the perceptions of girls. For example, girls may hear from the boys in the class that “boys are better at this” – whether through their actions or in actual teasing. For example, Sandler et al. (1996) reported that when girls do well on an assignment they are often questioned about whether or not they had help on the assignment. Boys, on the other hand, are asked this less frequently. Thus, girls construction of meaning and interpretations of their experiences with assessment, are complicated by the messages of teachers and peers within the classroom, which are powerful mediators of their developing beliefs. Other societal socializing may also be sending a negative message about girls in science, including signals from parents, the media, and even the depiction of men and women in their science books.

For teachers interested in raising the efficacy of girls in science, it means awareness that good, fair grades are not enough to offset prior and continuing socialization that science is “more for boys.” It may mean using, as Gilbert (1996) asserts, “girl friendly” techniques. This means actively combating stereotypes and the negative reinforcement that girls may be internalizing from a variety of sources. Establishing an orderly system for distributing supplies and helping students during autonomous learning situations where boys cannot seize the spotlight is another step. Creating a climate of “zero tolerance” for put-downs, and giving encouragement for good work in a variety of ways beyond grades on tests or homework is also important. Finally,

considering that so many science teachers are male (which again sends a gender message) the importance of bringing female role models to the classroom, emphasizing the achievements of women in science, and analyzing the depiction of women in texts and posters cannot be overstated.

Conclusions

The results of this study suggest that it is not enough to provide access to science for girls; nor do good grades ensure that girls will feel confident in their abilities in science. The entering and enduring perceptions the girls held about the assessment system is troubling because confidence in the assessment system is crucial for student participation and continuation in this discipline. When that confidence is violated, whether by overt teacher action or by teacher ambivalence to these perceptions, student ability to trust in their abilities is shattered, which can have significant negative consequences for learning and career pursuit.

Schools occupy an important place in the development of students' beliefs regarding their abilities and what is and is not an acceptable career path. Accordingly, students' beliefs can be a powerful predictor of the future action they will take. Bandura (1997) argued that the role of self-efficacy – the belief in one's ability to perform – is that “people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true” (p. 2). When we are assessed, we appraise our abilities and talents and plan courses of action on the basis of those beliefs. These beliefs, in turn, affect our expectancies for the future. When these perceptions are combined with the chilly climates reported by many girls in math and science classes, it is not difficult to imagine why girls do not pursue careers in these fields.

What can be done? Certainly schools need to alter the belief many girls hold about assessment in our science classrooms. The most obvious implication for teachers is that their grading system must not only *be* fair, but also as transparent as possible, within the limitations of confidentiality. Students who truly understand the basis of their grades (and the grades of their classmates) are more likely to believe in the fairness of the system. This study suggests that girls may need more feedback from science teachers, both in class and on tests, so they understand why their answers are right or wrong – as opposed to being left on their own to “feel stupid” or afraid to ask questions, as some girls in the study indicated.

Perhaps even more importantly, there are implications for climate – both within science classrooms, and extending throughout the school. Signs of a non-inclusive climate might include peer or teacher stereotyping that keeps students from exploring areas of interest, enrollment differentials in certain fields of study, or fewer girls seeking school leadership roles. Any of these could indicate a school-wide chilly climate for girls, and it is the responsibility of both teachers and school leaders to recognize these issues and take steps to establish a climate of inclusivity.

Limitations of the Present Study

Any self-reported information about perceptions among adolescents can be quite precarious, and their perceptions may be subject to influences not considered in this

study. Further, the results of this study represent a snapshot at two particular points in time in once school district and may not apply to other samples or populations.

Future Directions

If we want more women in the sciences, we need first to investigate the ways that the sciences are taught in our classrooms. Researchers and curriculum designers should investigate ways to change the curricula to reflect various learning styles and gender differences. Science teachers, specifically, must explore and implement more girl-friendly methods, which will help girls succeed as well as help them see their place in science. As Ball (2002) argued, “curricula that represent the “voices,” images, and historical experiences of traditionally underrepresented groups are particularly important.” And school leaders must better understand the ways in which climate affects participation in traditionally male-dominated disciplines, and take steps to alter any cultural norms that may be subtly discouraging girls.

The under-representation of women in the sciences must also be viewed from a broader contextual viewpoint. Future studies should include measures on self-perceptions, perceptions of subject matter, and ability beliefs. Attempts should also be made to disentangle perceptions and beliefs that are based on school-effects (e.g., assignments, teachers, previous achievement) and societal-effects (e.g., socialization within the context of society, family and peer group). In our view, we cannot fully understand the under-representation of women in the sciences without understanding the forces that operate at various levels: societal, educational, familial, and personal. Only then can we hope to ameliorate the effects of prior beliefs and perceptions on girls’ willingness to pursue science as a viable career option.

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