DOCUMENT RESUME

ED 393 705 SE 058 258

AUTHOR Larson, Jane O.
TITLE "I'm Just Not Interested": Gender-Related Responses in a High School Chemistry Curriculum.
PUB DATE Apr 96
NOTE 19p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (69th, St. Louis, MO, April 1, 1996).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Chemistry; *Classroom Environment; High Schools; *Science Education; *Sex Differences; *Student Attitudes
IDENTIFIERS *Gender Issues

ABSTRACT

This study deals with gender-related issues that became apparent within the context of a high school chemistry curriculum implementation. It documents observed differences in male and female responses to shared experiences in the course, and analyzes these reactions in light of research on gender in science education. Major areas of distinction in student reactions were noted in: work habits, classroom demeanor, response to chemistry activities such as labs and tests, attributions for success, attitudes toward chemistry, attitudes toward science, and decisions to remain in the science "pipeline." Female students' loss of confidence and interest led to negative attitudes manifested in decisions to exit the science track. Although the chemistry teacher attempted to maintain a positive learning environment, he apparently failed to meet the needs of his female students through gender-blind practices. Research literature that addresses these phenomena attempts to root them in cultural expectations and attitudes perpetuated in curricular materials, classroom interactions, and instruction. The complex network of determining factors in the chemistry class is investigated and suggestions for alleviating the loss of females from science education are discussed. (Author/JRH)

"I'm Just Not Interested": Gender-related Responses in a High School Chemistry Curriculum

Jane O. Larson

University of Colorado, Boulder

Mailing Address:
PSC 78 Box 4321
APO AP 96326

e-mail
R.LARSON1@genie.geis.com

A paper presented at the annual meeting of the National Association for Research in Science Teaching in St. Louis, MO on April 1, 1996.

"I'M JUST NOT INTERESTED": GENDER-RELATED RESPONSES IN A HIGH SCHOOL CHEMISTRY CURRICULUM

Jane O. Larson, University of Colorado

Within the context of a high school chemistry curriculum implementation, gender-related issues became apparent. This study documents observed differences in male and female responses to shared experiences in the course, and analyzes these reactions in light of research on gender in science education. Major areas of distinction in student reactions were noted in (a) work habits, (b) classroom demeanor, (c) response to chemistry activities such as labs and tests, (d) attributions for success, (e) attitudes toward chemistry, (f) attitudes toward science, (g) decisions to remain in the science 'pipeline'. Female students' loss of confidence and interest led to negative attitudes manifested in decisions to exit the science track. Although the chemistry teacher attempted to maintain a positive learning environment, he apparently failed to meet the needs of his female students through gender-blind practices. Research literature that addresses these phenomena attempts to root them in cultural expectations and attitudes perpetuated in curricular materials, classroom interactions, and instruction. The complex network of determining factors in the chemistry class is investigated, and suggestions for alleviating the loss of females from science education are discussed.

"I'm Just Not Interested": Gender-related Responses in a High School Chemistry Class

Introduction

As a science teacher with limited access to research literature, I became aware of sex discrimination in the classroom through the media. I learned about teachers' giving less praise to females, asking fewer questions of girls than boys, and demonstrating generally lower expectations for content mastery and future accomplishments of their female students. Convinced that my teaching efforts were equitable for all students, I took issue with such conclusions that blamed teachers for the shortages of females in science and technology careers. My fellow educators echoed my thoughts. They proudly pointed to high proportions of high achieving females in advanced science and math classes in our school. They challenged reports accusing them of fostering sexual stereotypes in classroom interactions. Such conditions may be prevalent in other schools, we retorted, but not in ours. However, as a Ph.D. candidate with direct access to literature concerning the gender issue, I began to see that the absence of females from science careers was related to their unexplained exit from the science 'pipeline' at crucial times in the schooling process (Oakes, 1990). Explanations for this "hemorrhaging" were varied and complex, calling for more research and analysis of the phenomenon. The issue thus became more substantial to me. Still, I felt it had no direct connection to me and my teacher colleagues who endeavored to provide equal treatment and opportunity to our students. This paper documents my unintended confrontation with the gender issue within classroom research for my dissertation on curriculum modulation. It describes my discovery of unexpected female-male responses within a chemistry class, and then attempts to explicate the complex network of determining factors that were responsible for variations in responses and related decisions to continue in, or exit from, the science track.

Objectives

The original objectives of my investigation were to examine the modulation of a chemistry curriculum in a single class by studying the intended curriculum, its implementation by the teacher, enactment within the classroom, and subsequent learning by the students. However, as participant observation continued through the year, obvious gender-related differences in student responses to the curriculum became obvious. This required an adjustment in focus to more accurately identify and explain the variations in male and female reactions to shared classroom experiences. In order to analyze data, additional objectives were adopted from Oakes' (1990) suggestions for further research on school social conditions related to women's participation in science and mathematics:

> What is the nature of girls' school and classroom experiences in science.. compared with boys' experiences?
>
> How do different school and classroom experiences relate to girls' attitudes toward science? to their achievement? to their further participation in science?
>
> What are the effects of various school and classroom experiences on the decisions of high-achieving girls to pursue study in quantitative fields? (Oakes, 1990, p. 208)

Design and Procedures

Setting and Participants

The site was Victory High School, a 7-12th grade school with an enrollment of about 700 students situated on a US military base overseas. Since the student body was composed mostly of military dependents, their socioeconomic status was fairly stable. Parents were employed and in good health; most appeared to support the educational objectives of the school. The school had a diverse ethnic student population, and, as in any school, ethnic and cultural differences sometimes exerted an influence upon the educational environment. An additional characteristic of the students was their mobile lifestyle, which translated into a great variety of educational experiences in their backgrounds. Since chemistry is the first science course which is not required for graduation, students who select it are demonstrating an intention to continue in science with the likely goal of college attendance. This "self-selective" factor, in addition to the math requirement, placed those considered more "able" into chemistry. However, the school did not prohibit entrance into the class on the basis of grades or perceived ability.

The seventh period chemistry class, in which I was a participant observer, had 23 students, 13 girls and 10 boys, most of whom were juniors. Most were concurrently enrolled in advanced mathematics. The teacher, Mr. London, had taught science for sixteen years, seven at Victory, and was well known and highly regarded in the school and community. When asked to participate in the study, he readily agreed.

Method

An ethnographic methodology was employed to study a chemistry curriculum as it was enacted within a classroom setting over the course of the school year. Data were collected in the form of daily fieldnotes. In addition, I kept a personal journal to reveal and confront personal biases, to tentatively examine data for developing themes, and to document my responses to classroom events. Classroom artifacts such as tests, labs and Learning Logs were collected. At mid-year, the Classroom Environment Scale (Moos and Trickett, 1987) was administered to Mr. London and the students in order to measure their perceptions of the classroom. Formal interviews were conducted with Mr. London through the year, and six students representing high, middle and low achievement levels were interviewed at the conclusion of the school year.

Data Analysis

Triangulated data were analyzed with a combination of methods. First, Spradley's (1980) domain analysis was employed to describe the cultural environment of the classroom. Three levels of analysis - descriptive, taxonomic and componential - were conducted on successive types of observations. This method is considered effective because it uses the perspectives of participants to understand their meaning systems. Along with this, data were analyzed on a continuous basis according to methods outlined by Erickson (1986). As data collection continued throughout the school year, additional questions were generated to serve as foci for subsequent observations and interviews. This review and interpretation process led to assertions which were tested against the data for confirming and refuting evidence. The assertions, both suggested and supported by the domains extracted from the data, thus represent a combination of researcher and participant perspectives.

Findings

The Classroom Environment

Three intertwined themes constituted Mr. London's conception of teaching science. The first theme defines his role as a teacher through the metaphor of the teacher as helper. The second is based upon the role of the student as an active, reflective thinker. The final theme emphasizes Mr. London's belief in the social construction of knowledge in the classroom. Mr. London believes the teacher promotes student learning in science by clarifying information. He accomplished this by asking questions to encourage students' reflection, by providing input and eliciting feedback, adjusting presentation of information, and helping students come to "their own answer." The role of the student is to encounter and interact with information in as many ways as possible. For example, learning is enhanced through hearing, seeing and writing information to make sense of new material. Experimenting, reflecting, questioning and grappling with material is essential for true understanding. Finally, Mr. London contends that active engagement of teacher and learners in science education leads to the social construction of knowledge. Through teacher-student interactions, education becomes a "two-way thing" in which he stimulates thinking. Student-student interactions in group problem solving sessions encourage discussion, questions and responses so students can "teach themselves." Permeating this constructivist conception of the science classroom is a general interpretation of science as experimentation. In Mr. London's definition, a lecture is not teaching, and rote memorization is not learning. The flexible, creative, developmental quality of science becomes a metaphor for the teaching-learning process in Mr. London's science classroom.

Mr. London described his role through the metaphor of teacher as helper, and this perception was sustained in his teaching strategies and classroom routines throughout the year. His emphasis on the social character of learning was exemplified in his reliance upon group work in which students read the material, worked out answers to assigned problems and discussed the concepts. As the helper, he encouraged the class to "use me" and "ask me questions." During class time, he constantly circulated among the groups, soliciting questions and prompting answers.

As the manager of chemistry teaching activities, Mr. London typically planned in text chapter "cycles." He would read through the text, check the practice problems and review questions, and prepare himself to answer questions. "I like them to attempt to read it so they get good and confused, and then we'll go back through and I'll ask them questions" (LI6). For the class, mini-lectures were used to introduce segments of the chapter either before or after reading assignments. Then students worked in groups to answer chapter review questions. A related lab activity followed, then more mini-lectures, questions, a review "for reinforcement," and a test. These chapter cycles encouraged students to interact with the material, their peers and Mr. London as they gained exposure to concepts.

In addition to regular daily assignments, Mr. London offered extra credit to students who kept a notebook each quarter. Since chemistry was emphasized as a "college prep class" in which students took responsibility for learning, he hoped to emphasize the benefits of organization in note-taking by rewarding up to five additional points on the quarter grade. Finally, Mr. London assigned quarterly research projects which required students to investigate an area of their curiosity, not necessarily in chemistry. He intended for them to gain knowledge of particular science topics as well as first hand experience with the processes of scientific inquiry.

As a participant observer student in the chemistry class I sat near the back of the room with a group of students with whom I worked on lab and homework assignments. This group included: Fatima, a bright, gregarious girl, and Tyler, her quiet, agreeable boyfriend; Betsy, Katrina and Mercedes, vivacious fun-loving girls, and Abe, their happy-go-lucky friend. Interestingly, this was the only co-ed group. Other students arranged themselves in single sex teams of three to six that split and reformed according to the type of activity in which they were engaged. For instance, in labs they worked in teams of two or three on each side of the lab stations, but for group chapter review sessions, the desks were placed in circles of four to seven. I was always busy taking copious field notes disguised as classnotes on chemistry, observing student interactions in learning chemistry, Mr. London's teaching of content, and general aspects of the classroom culture. Therefore, it came as a surprise to me when I expanded my field of view from my group to another during a lab on heat capacity in November, as revealed by an excerpt from fieldnotes:

> I circulate to other stations to see if they are as lost as I am. At the first lab station, Russell, Paul, Benjamin, Junior and Bob are working with gusto. I see them talking to Mr. London now, and he is asking them to find their percent error! This means they did the lab and were able to plug data into the formula which was on the overhead, do the calculations, find the Cp, look in the book to discover what kind of metal they had, then begin to find percent error for their findings. I was impressed. Most of the students at my end of the room never computed mass of the block or the water because they didn't know the formula entered into the process of filling in the data table (FN5, 5).

Gender-related Responses

It never occurred to me to distinguish the successful lab group from those less successful "at my end of the room" along gender lines. And it was not until the halfway point in the year that I realized the front and back sections of the classroom were divided not only by apparent interest in chemistry or tendency to socialize, but by gender. For mini-lectures which opened class, most of the boys sat in the first three seats of every row, and all the girls, with Abe and Tyler, sat behind them. In reexamination of the fieldnotes, I distinguished a pattern that, along with continued observations and year-end interviews, revealed gender divisions consistent with student-elected seating arrangement in the following areas:

Work habits. Males worked quietly in groups, appearing to be on-task, asking the teacher questions when necessary. Females gossiped and laughed as they cooperated on group assignments. In the lab, as described in the field notes above, males completed the procedures quickly and efficiently, much before the girls who giggled, played with equipment, and were often forced to 'improvise' data.

Classroom demeanor. During mini-lectures in which Mr. London used a 'rapid fire' speaking approach, the girls talked and passed notes while the boys, if they chose not to listen or take notes, slept on crossed arms on the desks. Because Mr. London rarely took an authoritarian stance, he did not ask for silence when he spoke, and his voice was often in competition with those of the girls. However, near the end of the year, his patience was waning. In the midst of an explanation of molecular bonding, he stopped suddenly and said to Celeste and Shelly, who were openly talking and creating an obvious disruption to the flow of the class,

> "Ladies hang on. People want to learn. Just leave. We don't need you." Four girls rose from their seats and left the room giggling. Mr. London continued with his discussion using an overhead transparency showing crystals. "The sharing, the attraction between molecules, is caused by Van der Waals forces..."(FN8A, 5).

When it was time to work on chapter review problems in groups, this was the typical scene:

> Mr. London is with Russell, Robert and Paul as they turn in some papers. He discusses the concepts with them and asks if they all agree on the answers on the sheet. They say yes. There is a minimum of fooling around with those guys. They appear to get the work done in a relatively serious manner. Big difference from the loud, often silly kids in the back of the room - mostly females (FN5A, 8)
>
> At the other 'boy' group, Robert rests his chin on crossed arms on the desk. Brian has his book closed. They explain that they had finished the questions yesterday and have nothing to do. Robert says, "This class always goes slow. You see on the clock 5 minutes left, and when you look back up ten minutes later, only 2 minutes are gone!" Brian agrees (FN5A, 5).

Response to chemistry activities such as labs and tests. If they encountered difficult questions on labs and tests, the girls whined, complained bitterly, or became angry. The boys, in contrast, did not openly protest. If they did not understand, they did not publicly admit it. In February, Mr. London gave an especially difficult test on chapters 8 and 9, dealing with per cent composition, empirical formulas, three types of reactions, solubility and balancing equations. Reported in fieldnotes:

> I like this kind of test and immediately get into the 'test taking mode,' treating it much like a contest between the teacher and myself. However, most students do not have my experience or confidence, and I guess they will find it frustrating and maybe defeating. I notice the boys in front work hard - Monty, Russell, Conrad, Brian James, Junior, Paul, Robert. However, the girls - including Celeste, Shelly, Ashley - those who care about grades and are generally successful - are very verbal with frustration, even anger. Ann, an independent sort, does one or two, and quits. She refuses to try any more. Later I see Monty showing a problem to Mr. London who nods as he views it (FN2A, 22).

At the opposite end of the scale, if a lab was fun or interesting, the girls did not hesitate to express their feelings, whereas the boys maintained a more composed demeanor. An excerpt from fieldnotes describes two lab stations with female groups:

> Carla has a bunch of balloons at the next lab table - a 2 month anniversary gift from her boyfriend. The six girls - Celeste and crew - are at the next station toward the door. I hear one describe the remains of one experiment as "bird doo doo." At one point the copper carbonate in the test tube pops out and the test tube breaks. Celeste says she is afraid, so Mr. London helps them. Much of the lab is again like a quilting bee - lots of talking about other kids, the social agenda being foremost in their minds (FN3A, 12).

Visible differences in male and female reactions to the chemistry class were recorded in fieldnotes and discussed in my personal journal as the year progressed. Since my original research plan called for six students to be interviewed at the end of the year, Mr. London and I selected three boys and three girls who represented high, medium and low levels of achievement in chemistry. All students agreed to participate in a private 30 to 45 minute interview which was taped and later transcribed for analysis. Again, responses displayed differences in attitudes and attributions that could be separated on the basis of gender. The following four categories elaborate these divisions:

Attributions for success and failure. The females insisted that students who were successful in science were naturally capable and therefore interested in chemistry. They consistently named males as examples of success. When they received a low test grade, the girls cited their lack of ability to master a subject that was "too hard." For example, Linda, the lowest achieving girl, admitted she didn't study for tests. When asked if she didn't care about her grade, she responded,

> Well, I do want to get a higher grade - I just don't understand it, it doesn't make sense to me. That's why I don't really..it's all chemical. I'm not interested in that. All I worry about is to get out of that class and pass it (p. 2).

When asked if there were any students in the class who liked chemistry, Linda thought that Cliff probably did, "Because he's smart. Well, isn't he getting good grades? I guess I would too if I understand it."

The complex relationship between interest, ability and success was also mentioned by Shelly, the mid-level female. When asked to respond to the statement, "I enjoy learning chemistry in school," she replied:

> I don't know, I think chemistry...it must have to come natural, because it doesn't come..I mean, I like science, but the chemistry portion... I just don't deal with chemicals. I have to study. I guess I just don't have that much <u>interest</u> in chemistry (p. 7).

Celeste, the highest achieving female student, also stated that she was not interested in chemistry because, "I guess because...it's hard, so I just close my mind. I don't want to try, because I don't <u>get</u> it." Reminded that she had earned an A in the class, she explained,

> Yeah, but my tests...I don't understand. I mean, I get an A because I do my work, but as for like, if you could grade me on how much I <u>know</u>, I'd get an F, because I fail my tests, but I do everything else, like my labs...I don't understand it (p. 2).

Asked why some students liked the subject, she answered,

> Because they're brains. They like to do all that..I mean, the really smart people in our class, they are <u>good</u> in math, too. And they're like those 'engineer-kinda-type' people who like chemistry...but I don't know, I just don't like chemistry..but I'm good at math, but I don't like chemistry, so never mind (p. 10).

The females' explanations can be summarized by linking natural ability, or "brains," as the essential factor, to interest and resulting success. In their minds, when a subject "comes natural," a student will develop interest, expend effort, and achieve high grades.

Males, on the other hand, cited their lack of interest, rather than ability, as reason for their lack of high grades. Brian James was an average chemistry student. In the interview he stated that, "For true learning, you need effort." Interest was related to effort.

> Interest. You've got to be interested in it. That's why lots of people have different grades. Like some people do really well in a subject and don't do really well in another because they might not be as interested in the other subject. And if you're not interested in it, you're not going to want to pursue it (p. 7).

Brian James used this philosophy to explain his lack of interest in chemistry:

> It's not that I really don't enjoy it - it's just, I don't know, I'm really lazy I guess. I don't like schoolwork and systematic stuff..I'd rather be outside learning or something (p. 11).

Abe, the carefree student who could be found in the midst of any disturbance and who was most often reprimanded by Mr. London, readily admitted he often failed to take notes, was disorganized, was "kicked out of the computer room a lot," and slept during lectures. His inability to pay attention, he averred, was based on the fact that

> I get a little hyper and stuff, because you're with your friends and stuff, and so that's why I was probably going crazy, ...I get off the subject, and talking about friends and school and family and problems and stuff. (p. 5).

Abe's response to the statement, "I enjoy learning chemistry in school" was, "That's between true and false." He explained that chemistry was "really fun, real interesting," "but sometimes it gets boring, ...kind of dry, and I really didn't like, like didn't want to learn it" (p. 10). Similar to Brian James, he believed that,

> Those who are interested in chemistry, learn a lot of stuff...Yeah, if you really end up putting time in to chemistry, you're really interested in it and stuff, you'll like it. But if you really don't care about it, you really don't have interest in it (p. 11).

Monty distinguished himself as the highest scoring student in the class. He was a serious student who listened in class, asked frequent questions, reviewed the lessons at night and kept a complete notebook. "I have a pretty good grasp of it. That's the way my mind works, is logically, scientifically. I can understand it real easy" (p. 1). When asked why some students did not like chemistry, Monty responded,

> Well, students probably don't like chemistry because it's a very difficult subject to understand, and there's a lot of facts that you do need to memorize, and they're just too lazy to do it (p. 9).

Thus, for the males, ability to master the course was never questioned. Interest was the critical factor for one's success in mastering any subject. Interest determined the amount of effort expended to learn the subject, directly affecting a student's grades. Thus, a lack of effort, rather than of ability, resulted in failure.

Attitudes toward chemistry. By the end of the year students were consistent in their evaluations of chemistry as uninteresting and unrelated to their lives. However, the males regarded the course as a stepping stone to future careers while some of the girls perceived it as a barrier to future science courses and/or careers in science.

Monty: It's required. And it's recommended for college. I plan on majoring in engineering, so I have to take as much science as I can (p. 9).

Linda: No, I don't enjoy it. It doesn't have anything to do with what I do (p. 9).

Shelly: So I can understand if someone's really nosey and they like figuring out things, finding things and seeing why this works with this -- chemistry is good for them. But if you're like myself, then you don't want to know what chemical bond is going to bond with what. I think chemistry's no good (p. 8). Like I say, I was not born liking chemistry. But ever since I ever took it, I never liked it. I never liked it (p. 10).

Celeste (in response to the statement, The science I learn in school has little in common with my life outside school): True. Yeah, now it does, now. Before when I was younger, it used to. I don't really care about science any more. It's not that I don't care, it's just..Because I don't like chemistry, that's why. But other sciences, like biology, that relates to every day (p. 8).

Attitudes toward science. By extending their feelings about chemistry to science in general, the girls began to think of science as out of their reach, distant and therefore not worth pursuing. The boys saw science as the essence of everyday life, important for explaining our world and viable as a career. The girls weren't so sure about the impact of science upon their lives.

Decisions to remain in the science pipeline. All of the males who were interviewed planned to attend college and study science in some form. To that end, they planned to enroll in physics their senior year. Although some girls did not question their continued presence in the science track, others, like Celeste, were deterred by their perceived failure to learn chemistry (despite good grades), and they abandoned previous plans to take physics, major in science in college and continue into science careers.

Interviewer: Science is a valuable and important subject.

Monty: Yes, it is, because you can understand your surroundings, because if you don't, you'll be ignorant and you won't ever try to change it. If you know you can control it and you know how you can do it, then you'll feel more confident about it (p. 9).

Brian James: Yes it is, because it tells us about our past, and it also tells us about what we can do in the future. Technology is based on science, and almost everything around us now is a product of technology - so science is very important for understanding what we can do and understanding what we shouldn't do and what we need to do (p. 12). Yes, I plan to study more science. Definitely more science - probably more math, too (p. 11).

Abe: You see science everywhere you go, everything you do. Yeah, it's connected. You can't escape science. I'm taking physics next year, and an engineering class. Yeah, I'll be studying science (p. 10).

Linda: Biology is (a valuable and important subject). Chemistry, I guess. They help you understand things. I learned something in biology, I think.

Shelly: I just think it (science) doesn't have like a big major effect, like living or dying and anything, but it just makes you look at things with a wider variety. And my goals as far as after graduation, I plan to be an accountant and major in accounting, in business. Take more science? Uh-huh. I like science, I really like science -- I just don't like chemistry (p. 7).

Celeste: Yes, that's true. It is. Because...it's neat! Science is neat. It's not always just straight, like Okay, say math, if you add, you always get...If you have five plus five, you have to get ten. Science does different things, and you can always..Like science, you always have to go through things and see what they're all about and test things and stuff. That's why I think science is neat. So I like to do - like when I took that science research course, because I like to do experiments and stuff like that, see how things turn out. That's the kind of science I like (p. 10).

Interviewer: When you finish high school, what do you want to do?

Celeste: I don't know. I used to want to be a scientist, when I was in elementary school. And then once I got to high school, it kind of changed. I guess, I don't know, I lost interest, but now I either probably want to be an accountant or something like...Well, I don't know if this is really science, but psychology, because, I don't know, I like to talk to people (p. 2).

In summary, the ways in which students worked, responded to and explained their reactions within the chemistry class are readily distinguished by gender. The males appeared more restrained in classroom interactions, more confident in their abilities, and more certain of their success in future endeavors in college and science careers. On the other hand, the female students were often impulsive during class activities, exhibited a loss of confidence as the year progressed, and began to question their continued enrollment in high school science classes. When the physics teacher visited the class to create interest in his class, the boys immediately stated their plans to enroll for the coming year. Most girls would not commit themselves, saying they feared low grades, a course that is too hard, and the impact upon their GPA's. The next section develops interpretations of these phenomena in relation to recent educational research on gender.

Interpretations

Realizing that females and males displayed unique responses within the chemistry curriculum enactment, I consulted recent research on gender bias in schools and was surprised to discover the correlations of my data with those of others. The explanations fell into three general categories of sociocultural variables, affective variables, and educational variables.

Sociocultural Variables

In the observable categories of work habits, classroom demeanor, and response to chemistry activities, the girls in my study were more demonstrative, lively, and aggressive than males. Roychoudhury, Tippins, and Nichols (1995) documented similar differences in their college students' reactions to their gender-sensitive physical science course. Whereas the females enthusiastically commented on their experiences in the course, the male students did not express excitement. "The explanation for this lack of excitement in the comments of the male students probably stems for the social construction of male roles and the expectations thereof" (Roychoudhury, Tippins and Nichols, 1995, p 917). It is logical to extend this explanation to seventeen-year-old chemistry students undoubtedly sensitive to such culturally based roles. Considering analyses of the science gender gap that place sociocultural variables as central to differential achievement and participation of boy and girls in science (Oakes, 1990; AAUW, 1992; Kahle and Meece, 1994), influences such as sexual stereotypes must at least partially account for gender differences within a classroom.

Affective Variables

Of greater import, however, is the role of affective factors in gender response variations. Issues of confidence, interest, attitude, attributions, self concept and performance abound in the literature. Kahle and Meece (1994) report on studies that attribute the gender gap in science achievement to the nature of tests. For instance, males tend to perform better on objective tests and females score higher on essay tests. The type of test which elicited girls' frustration and anger in the chemistry classroom contained mathematically-based objective items. Therefore, it was not surprising that the girls fared less well on the tests. Oakes (1990) reports extensively on confidence, citing research that reveals girls to be less confident in their ability, more apt to give up when experiencing difficulty, and "especially insecure about their prospects for success on tasks they see as requiring high ability and on unfamiliar or difficult tasks" (p. 175). All of these behaviors were evident in Mr. London's chemistry class.

The chemistry students' attributions for success and failure also fit the patterns established in previous research. The conclusions that girls attribute their success to luck or effort and their failure to their own inadequacies or lack of ability are echoed through the literature (Oakes, 1990; Tobias, 1990; Sadker, Sadker and Klein, 1991; AAUW, 1992). Boys, on the other hand, frequently perceive success as the result of ability, and failure as a lack of effort. Oakes (1990) and Tobias (1990) distinguish the male attributions for failure as external, for instance, blaming the difficult nature of a subject or poor instruction. Females, however, tend to blame personal, "internal" factors for their lack of success. These reactions, state Sadker, Sadker and Klein (1987), give boys a sense of mastery and control over their fate, increasing self confidence and persistence. In contrast, the AAUW (1992) reports, females have a higher expectancy of failure than do males with similar abilities.

Other affective factors involve the complex relationships between ability, interest, and achievement. In the present study, girls stated that one's ability (or lack of it) directly determined his/her interest in chemistry, thus affecting success. However, the boys believed that one's interest in a subject influenced the amount of effort applied to learning it and the resulting performance. In her study of the "second tier," a group of competent students who originally chose not to major in science, Tobias (1990) reports that the Lipson Study, a secondary analysis of the data, identified a complex relationship between performance, interests, and motivation as a major theme. Like the girls in the chemistry class, "switchers" who had switched from science to nonscience majors, emphasized the influence of their performance upon motivations and interests "rather than the other way around" (p. 78). In other words, their performance, interpreted as ability, drove the interest and effort applied to studying science. However, Oakes (1990) reports studies that conclude that girls may be less successful in science because they like the subjects less, restating the views of the male chemistry students that interest drives achievement. Further, Eccles' academic choice model, described in Kahle and Meece (1994), depicts environmental factors such as causal attribution patterns, gender role stereotypes, and perception of tasks as contributors to an individual's perceived value of an activity and expectations for success or failure. These, in turn, influence the amount of effort applied, the performance level achieved, and the decision to participate in the activity. Ultimately, effort and performance affect girls' subject choices (Kahle and Meece, 1994, p. 553) and their persistence in science courses and careers (Oakes, 1990, p. 159). Therefore, research supports conclusions that interest and effort are determinants of successful performance. Girls appear to be blaming nonexistent inadequacies for their lack of success in science, and exiting the pipeline in frustration.

Weinburgh (1995) reports data suggesting a "moderate" correlation between attitude toward science and achievement in science. The correlation between attitude and behavior, she states, is "somewhat stronger for girls than for boys, indicating that a positive attitude is more necessary for girls in achieving high scores" (p. 395). The relationship between attitude and achievement becomes greater, says Oakes (1990), when achievement in controlled. Women appear to leave the science pipeline at higher rates that men of equal science ability. Thus, "when other factors are taken into consideration, attitudes may play a critical role in high-achieving women's leaving science" (Oakes, 1990, p. 179). If the abilities of Celeste and Monty are considered equal, Celeste's dropping out of the science track adheres to the pattern of this inference.

Educational Variables

Logically, the focus of research on the gender gap in science and mathematics must encompass classroom interactions. In this area, the most prominent findings describe teachers providing boys with more instructional time in the form of interactions, recognition, encouragement, higher levels of attention and expectations (Oakes, 1990; Sadker, Sadker and Klein, 1991; AAUW, 1992; Kahle and Meece, 1994). In terms of strategies, teachers who advocate cooperative learning, assign projects to allow investigation in areas of personal interest, and reduce competition are regarded as promoting "female-friendly" environments (Roychoudhury, Tippins, and Nichols, 1995). Avoiding sexist language and showing fairness in treatment and expectations to encourage girls (AAUW, 1990) also characterize gender-equitable learning environments.

Mr. London attempted to maintain a fair, positive classroom environment. Unlike many chemistry classes, competition was kept to a minimum. Students completed chapter review questions in group settings, collaborated on laboratory reports and even took group tests as a prelude to individual tests of content mastery. Like the gender-sensitive classroom described above, he assigned quarterly projects for which students could select topics of their choice and work with partners. When girls created successful projects, he was quick to praise them, even suggesting they enter the project into a local science symposium. In addition, Mr. London often tied content to real life applications in his mini-lectures, a practice believed to create girls' interest in science. Thus, if we assume that most students' dislike of chemistry and some girls' decisions to drop out of science in the coming year were engendered within the classroom in which they shared chemistry experiences, we must identify other factors that may have contributed to the formation of these attitudes. Although Kahle and Meece (1994) point out the difficulty of discovering the causes of gender differences in science participation and achievement, and Oakes (1990) emphasizes that no single factor can be attributed to the phenomenon, a review of fieldnotes reveals possible sources of attitudinal differences by gender. Some of these can be considered errors of commission, and some, errors of omission.

Sexist Language. Mr. London wanted his students to enjoy science, to feel at ease and not fear the content of chemistry or the 'mysteries' of scientific investigation. Thus. he often used informal language to have the students "relax." Also, apparently aware of research findings that demonstrated inequities in science classrooms, he made attempts to include females in his discussions of scientific inquiry. Another of his techniques was to use analogies which he believed would be interesting, even humorous, to the class. Upon further examination, all of these strategies cast a sexist tone within the classroom culture.

First, during student presentations of research reports, Mr. London often added relevant information for the students to ponder. Once he discussed pyrotechnics and mentioned "these guys...or ladies... who test fireworks." (FN4, p.1). I caught the reference and made note of his obvious attempt to include females in what may be considered a masculine occupation. Later, after a student project report on rice, Mr. London said, "I met a scientist doing research - a woman - on rice. It's actually high tech. Women are allowed to do research, too" (FN4, p. 17). I realized what he was doing, but I questioned his tone. To me it appeared to be slightly sarcastic, even patronizing to the females in the class.

The most obviously sexist language was in the frequent use of male-female analogies to explain atomic and molecular attractions. Examples include:

> Think of it this way - as marriage. Now you're single, doing your own thing. Then you get married, become a compound. You no longer have individual traits (FN3,10).
>
> The neutron, like a married couple, settles in with the proton (FN7,6).

> The number of protons is important. Mr. Electron hangs around..Katrina likes to have a boyfriend and also female friends (FN8,2).
>
> Attractive force. See how guys want to go with girls (FN8,7).
>
> Look on page 219 at the list. Which one is more reactive, more likely to hold on to a partner? Think of girls on a date - they are more active - more likely to hold on (FN2A,15).
>
> Using a "ball and stick model" Mr. London makes a molecule with a red zinc having 2 prongs, a blue silver with one prong, and a nitrate with a hole. "See what happens. Just like sex - you guys remember it any way you can! These two cannot mate - there is no hole" (FN3A,2).
>
> In discussing the differences in atomic radii, Mr. London uses an example of Abe as a "Chippendale guy" and then brings Benjamin and Junior in, describing how like a nucleus, with more protons, the guys attract more females (electrons) with their increased positive charge, and the group contracts as the girls move closer. I was surprised that there was not much audible or visible reaction from the class on this (FN7A,2).

Although intended to be a source of humor for all students, these analogies clearly place females in a unfavorable position. The sexist messages came through to me, but I never heard them discussed by the students. Nevertheless, potentially harmful implicit impressions were expressed.

Intentional Teacher Behaviors

Sadker, Sadker, and Klein (1991) close their review of gender research with suggestions for creating gender-sensitive classroom environments. They advocate "intentional teacher behaviors" that include teaching "directly about the restrictions of sex stereotyping and different gender communication patterns" as a way to encourage equitable relationships and interactions in mixed gender work groups (p. 307). Along this line, Guzzetti and Williams (1996) point out that "despite a teacher's intentions to be gender fair, the culture of the classroom may subvert or override these attempts" (p. 17). In their study, strong male personalities created "overt sexism" in lab settings and class discussions. Thus, to prevent sexism, it is essential that the teacher assume an active role in describing and creating an equitable classroom environment.

Mr. London did not become an active agent for the females in his class. For example, by failing to specifically acknowledge and encourage academically talented girls who expressed frustration with the chemistry course, he unwittingly aided their exit from the science track. Although the male students did not appear to express sexist attitudes, most of them separated into single gender groups, creating an image of themselves as serious, unapproachable students. Mr. London never attempted to change the arrangement of the groups into mixed gender settings. In another way, Mr. London's benign attitude toward the girls may have reflected his lower expectations for them. Reluctant to be an authoritarian, he seldom required the talkers, mostly girls, to be quiet when he began mini-lectures. He hoped to gain their attention simply by taking in competition with them. Most of the time he was successful, but a few girls continued to talk, write notes, or do homework for other classes. By asserting his expectations that everyone listen, question, and provide feedback, he would have included the females with the already attentive males in the front of the room. Allowing the girls to be off-task could be interpreted as lowered expectations of and for them. In this case, not encouraging girls may be as influential on girls' participation in science as actively dissuading them (Brickhouse, Carter and Scantlebury, 1990). In addition, because the girls were frequently off-task during group sessions, Mr. London unintentionally provided more guidance and higher level assistance to those students who asked content-related questions. The classic pattern of inequitable treatment for males and females was thus continued by a reluctance to require the girls to concentrate on academic matters.

Thus, through explicit and implicit language and actions, Mr. London unwittingly created conditions that allowed inequities to continue, fostering prominent differences in male and female responses within the chemistry curriculum enactment, and inadvertently prompting the unfortunate exit of some talented females from the science pipeline.

Discussion and Implications

This study was significant to me both as a practitioner and as a researcher for the following reasons. First, although I had denied the presence of gender inequities in the science classrooms of responsible educators, I discovered that they indeed exist in many forms. Good intentions to make students feel at home, to interest them with colloquial language, and to provide them freedom and responsibility for their own learning can create conditions that are ultimately inequitable for females and detrimental to their persistence in science and technology courses and careers. Sexist language may enter into lectures and classroom discussions. Differential expectations can be expressed and fulfilled by a teacher's reluctance to maintain equal standards for both male and females in classroom behavior. Thus, teachers must carefully examine their use of language and scrutinize their practice for possible bias, and teacher educators must increase their students' awareness of the subtle forms of sexism that can develop in the classroom. In addition to eradicating potentially damaging practices, teachers must develop and employ behaviors that specifically address inequities in student-student and student-teacher interactions so that all members of the classroom culture understand the devastating effect of gender bias, intentional or not. Finally, research and conclusions on gender-sensitive environments must be disseminated in schools so that teachers, counselors and administrators can learn how to actively improve self-confidence and encourage contributions of females to the fields of science, mathematics and technology.

> The absence of attention to girls in the current educational debate suggests that girls and boys have identical educational experiences in school. Nothing could be further from the truth (American Association of University Women, 1992, p. 2).

References

American Association of University Women (1992). *How schools shortchange girls.* Washington, D.C.: AAUW.

Brickhouse, N. W., Carter, C. S., and Scantlebury, K. C. (1990). Women and chemistry: Shifting the equilibrium toward success. *Journal of Chemical Education,* 67(2), 116-118.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching (3rd ed.,*. pp.119-161). New York: Macmillan Publishing Co.

Guzzetti, B. J. and Williams, W. O. (1996). Gender, text, and discussion: Examining intellectual safety in the science classroom.

Kahle, J. B. and Meece, J. (1994). Research on gender issues in the classroom. In Gabel, D. L. (Ed.), *Handbook of research on science teaching and learning.* New York: Macmillan.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. In Cazden, C. B. (Ed.) *Review of Research in Education,* 16, 153-222.

Roychoudhury, A., Tippins, D. J. and Nichols, S. E. (1995). Gender-inclusive science teaching: A feminist-constructivist approach. *Journal of Research in Science Teaching,* 32(9), 897-924.

Sadker, M., Sadker, D. and Klein, S. (1991). The issue of gender in elementary and secondary education. In Cazden, C. B. (Ed.), *Review of Research in Education,* 17, 269-334.

Spradley, J. P. (1980). *Participant observation.* Fort Worth: Harcourt Brace Jovanovich College Publishers.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier.* Tucson, AZ: Research Corporation.