Why Are There So Few Female Physicists?

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"In my younger days, when I was pained by the half-educated, loose and inaccurate ways that we [women] had, I used to say, 'How much women need exact science.' But since I have known some workers in science who were not always true to the teachings of nature, who have loved self more than science, I have now said, 'How much science needs women.'"[1]

–Maria Mitchell

It is 1962 and an adolescent female is trying to decide what classes to take; the principal asserts, "a girl has no need for physics."[2] School counselors or administrators may no longer make statements like this; however, the perception that shaped the principal's comment may be part of hidden and subtle discriminatory attitudes still active in today's schools. The point of this paper is to reveal and assess current attitudes toward female participation in physics education and suggest practices to ensure a fair environment for both males and females.

Assumptions this Paper Is Based Upon

1. Females are just as capable as males at learning physics concepts. Some observers have stated that women do not have the innate capabilities that men have to learn physical concepts. Research by Labudde showed that although males and females may have different backgrounds, when starting their physics education students have similar "spatial and language abilities."[3]
2. The large discrepancies in the number of females participating in physics are a result of social and environmental factors that can be changed.
3. It is in the best interest of the pursuit of knowledge in science to ensure that females and males are encouraged in the physics classroom.

Many factors besides gender influence the high school physics classroom, such as race, ethnicity, socioeconomic status, discipline records, and urban versus rural school environments.[4] However, in order to confine the topic for this paper, it was necessary to concentrate on gender. In addition, while the paper focuses on the problems specific to physics education, it is important to take note that the physics classroom and physics students are influenced by the culture at large.

Encouragement to Take Physics and Math Classes

The first step to creating a fair classroom environment is to ensure that both males and females are present in high-level physics and math classes. Counselors and parents are the most important people to encourage female students to take these classes.

Many female students do not receive the same level of math instruction as their male peers, and thus do not have the same foundation to study physics. Experimental research has shown that girls are not identified for their abilities in mathematics and science in the same proportion as boys (and boys are not identified for their talents in English, languages, or the arts).[5] It is the job of counselors to encourage students to pursue a variety of classes, and they must encourage females to take a variety of high-level math and science

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classes.[6] Another way to support these females is to provide them with mentors and role models, however limited they may be.[7]

A study by Horn and Chen found that children whose parents were involved with their studies were more likely to continue on to postsecondary education.[8] The impact of parental encouragement is clear—if parents do not expect their daughter to study science because she is a female, this will have a powerful influence on the types of courses their child will have a desire to study. It is not enough for a parent to be neutral with regard to the classes a female is trying to take. In order to overcome the social pressures to avoid specific classes, parents must be active supporters of their child involving herself in math and physics classes.

The Classroom Environment – General Female Involvement

Though males and females can both excel in physics, the two sexes are socialized differently in our culture and thus relate differently to their teachers, their peers, and their classroom environment. Many females feel a social pressure to hide their intellect in a public or school setting.[9] Interviewers who traveled the country heard many female students express "the pressures to be 'nice' and quiet, to get along with everyone, to avoid conflict or even notice."[10] Guzzetti writes strongly about how females' "lack of presence [in the classroom] was evidenced by the absence of their voice in classroom discussions, their physical seating away from the teacher, their withdrawal from class activity, and, in some cases, by absenteeism."[11] This was also seen in observations by Brown when interviewing Theresa, a physics student, who referred to her place in the classroom as "invisibility,"[12] or by other females who felt mistreated by fellow students.[4] These interactions, because they are part of an ongoing struggle that female students face on a daily basis, affect the levels of involvement they are willing to put into the classroom. Thus, if females even *think* that they perceive discrimination in their classroom, they will be less likely to apply themselves to their studies[13] and less likely to take science classes in the future.[14] We must examine how students treat females in the classroom, and find ways for teachers to encourage females in physics.

The Classroom Environment — Peers and Working Groups

Interestingly, though past research in the field hypothesized that gender roles will become less pronounced when students are arranged in small groups, they can actually become more prominent when the females are the minority in a group.[13] A separate study concluded that females did not speak more in small groups than they did in discussions with the entire classroom.[4] This is consistent with the idea that children can be assertive enforcers of their own gender roles.

In order to explore these concepts further, I sent out a survey (with Institutional Review Board approval) to high school physics teachers asking them a variety of questions regarding gender roles in their classrooms. One physics teacher, in response to a question asking if he observed stereotypical gender actions when students worked in lab groups, wrote, "Some of the females will allow a male to take over the equipment and 'run' the lab…. I have had very few females take over the experiments." Another teacher wrote, "Sometimes the girls let the guys take charge and just sit passively."

Based on these observations, single-sex grouping in small groups is one solution to these disparities. If laboratory groups are arranged according to sex, members of both genders are forced to be the observer and machine worker, secretary and facilitator.

A way to help the students express their thoughts on how they are being treated in class, both by teachers and other students, is to have them write a journal entry once a week. One female teacher did this in her single-sex physics classroom and asked students to write about what they had learned and also to discuss their learning environment.[15] In this way, students have a space to discuss explicitly gender issues they are encountering with their peers without forcing them to speak up in front of their peers.

The Classroom Environment — Teachers

The teacher provides a vital function in the physics classroom by setting the precedent for acceptable classroom behavior. Teachers play a role in the maintenance of gender roles, as they are part of the culture at large and often unknowingly support gender biases.

Though the teachers may be unaware, the students are not. "In a recent survey, students in Michigan were asked, 'Are there any policies, practices, including the behavior of teachers in classrooms, that have the effect of treating students differently based on their sex?' One hundred percent of the middle school and 82% of the high school students responding said 'yes.'"[16] A study by Rosenthal and Jacobson showed that a teacher's perception of a student's capabilities at the beginning of the year influenced a student's outcome in her class.[17] There is also evidence that teachers spend more time listening to an answer from a male student than from a female student.[18]

The teaching style an instructor chooses affects female involvement in the classroom. Refutational discussion is a common tool in physics; this method asks students to debate each other regarding a topic, and a specific student is often asked before class to have a determined opinion that is wrong. Refutational learning can be powerful because it encourages the students to support their own opinions and thoughts. However, a study found that only 30% of females (50% of males) stated they were "likely to argue a point" in a physics classroom,[19] so this type of learning can serve to increase gender inequalities. A group performed research on ways that students learn and found that written forms of refutation were one of the most useful ways for students to change their invalid, preconceived notions.[20] While it is important for students to speak up and explain their beliefs in a classroom discussion, it can also be useful for students to perform these tasks in writing.

Other teaching tools that could be useful to assist in overcoming gender stereotypes in the classroom are "report talk" and "circle talk." Report talk[21] is a traditional style where a teacher lectures the students. This can be a useful tool for teaching difficult physics concepts that students need to learn, but this method does not engage all of the students or force them to connect to the material. Circle talk[21] is a style where the students sit in a circle and discuss concepts, ideas, and questions they have with the materials. Circle talk can be used to determine the thought processes of students, and help them discover concepts for themselves.

It is important to understand that the majority of students, both male and female, do not gain as much of an understanding of the physics material if they are not active participants in the classroom. Williams examined the levels of speaking in a college physics class and compared those to how well a student's knowledge of a specific subject matter in physics improved. Her research concluded that the higher students' level of apprehension toward participation, the smaller the increase in their pre- and post-test testing for a specific topic.[22]

So, how can teachers ensure that their physics classroom is more open to female involvement? If one of the main issues, as we saw in a previous reference, is that teachers give females less time to answer a question than males, then simply allowing students, both male and female, more time to answer questions should help.[23] Stadler et al. recommend asking questions that relate more to daily life.[24] These researchers believe females are more likely to answer questions of this sort because they more likely to relate physics to the outside world, an idea that many educators have noted. Lastly, using a variety of teaching methods, and understanding the shortfalls of each, is vital to an instructor having the largest impact on all students.

Conclusion: Further Pursuits and Encouragement

The failure of the secondary school system to fully engage female learners in physics classrooms has a long-term impact in the students' lives. However, even if we fix the high school physics classroom, we can see that master's and Ph.D. programs can be sexist.[25] Furthermore, "women are disadvantaged by structural obstacles, such as lower-status positions, lower pay, and limited access to key social and professional networks."[26] Therefore, not only can the graduate school environment be hostile, but women have less promising futures in the field of physics, which could certainly lower their interest in pursuing the subject. Though we must start with improving the high school physics classroom, much work will remain once all students are properly supported and educated in their first year of physics.

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