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Problem Based Learning as a Tool in Addressing Gender Bias

Dr. Claire Lynne McCullough, University of Tennessee, Chattanooga

Dr. McCullough received her bachelor's, master's, and Ph.D. degrees in electrical engineering from Vanderbilt, Georgia Institute of Technology and the University of Tennessee, respectively, and is a registered professional engineer in the state of Alabama. She is a member of I.E.E.E., Tau Beta Pi, Sigma Xi, and Eta Kappa Nu. She is currently a Professor of Computer Science and Engineering at the University of Tennessee in Chattanooga, and teaches courses in such areas as Computer Ethics, Controls, and Engineering Design. Dr. McCullough has over 30 years' experience in engineering practice and education, including industrial experience at the Tennessee Valley Authority and the US Army Space and Missile Defense Command. Her research interests include Image and Data Fusion, Automatic Target Recognition, and Bioinformatics. She is a member of the ABET Engineering Accreditation Commission, and is on the board of the Women in Engineering Division of ASEE.

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Abstract

After decades of addressing the gender bias in engineering and computer fields, there are expectations, particularly by women in these fields, that the biases would have been eradicated long before 2014. However, an Implicit Association assignment[1] addressing the Gender Gap in multiple recent semesters of a Computer Ethics class produced results which the author found both surprising and disturbing in the biases reflected, and justified, by current students. As a strategy in dealing with this, Problem Based Learning (PBL) was used as the basis of a more extensive, team-based project in the Spring 2014 iteration of the class. The three-week assignment included a preliminary assessment, a group research project, an evaluation of team members, and a follow-up assessment to determine whether the project had changed any student attitudes. The paper discusses specifics of the reasons for the PBL approach, a brief description of the characteristics of Problem Based Learning, details of the multi-part assignment, results from the Spring 2014 class, and proposed refinements for future iterations.

The Problem of Under-Representation

Many studies have been performed by a variety of researchers trying to understand the factors that affect the lack of representation of women in science, technology, engineering, and mathematics (STEM) fields. The complex and somewhat convoluted diagram in Figure 1, from "Women's Underrepresentation in Science: Sociocultural and Biological Considerations" in *Psychological Bulletin*, illustrates the multifaceted nature of the problem. It has been hypothesized that relevant factors include items such as life choices, lack of interest, effects of hormones, gatekeeper test results, lack of support, external bias, and lack of information about STEM fields, but no consensus exists as to exactly what factors contribute to the gender gap, and what roles they play. For example, it has been suggested that women's under-representation in STEM fields is tied to cognitive differences in higher-level mathematics, but it has not been conclusively demonstrated that significant differences exist, extent of differences in areas like spatial ability, whether any differences can be remediated, and whether differences are relevant to success.[2] The numbers involved in the gender gap in computer science are substantial and growing. The gender gap has been slowly decreasing in most STEM fields, with some, such as biological sciences, showing significant gains, leading some to believe that time will solve the problem. However, the number of women in computer science peaked in 1986, and has been significantly *decreasing* ever since.[3] Thus, at least in the case of computer science, some positive action must be taken if the gender gap is to be closed.

The shortage of women occurs at all levels, as noted in the report "Why So Few? Women in Science, Technology, Engineering, and Mathematics" published by the American Association of University Women:

> In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. Among first-year college students, women are much less likely than men to

> say that they intend to major in science, technology, engineering, or math.... By graduation, men outnumber women in nearly every science and engineering field, and in some, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20 percent of bachelor's degrees. Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace. [4]

Given the variety of factors to which the under-representation of women in STEM has been attributed, a wide range of programs have been offered to remediate the problem. Approaches include both formal and informal education opportunities, mentoring, introduction of positive role models, hands-on explorations, industry interactions, scholarship programs, internships, and inclusion of families to affect attitudes.[4]

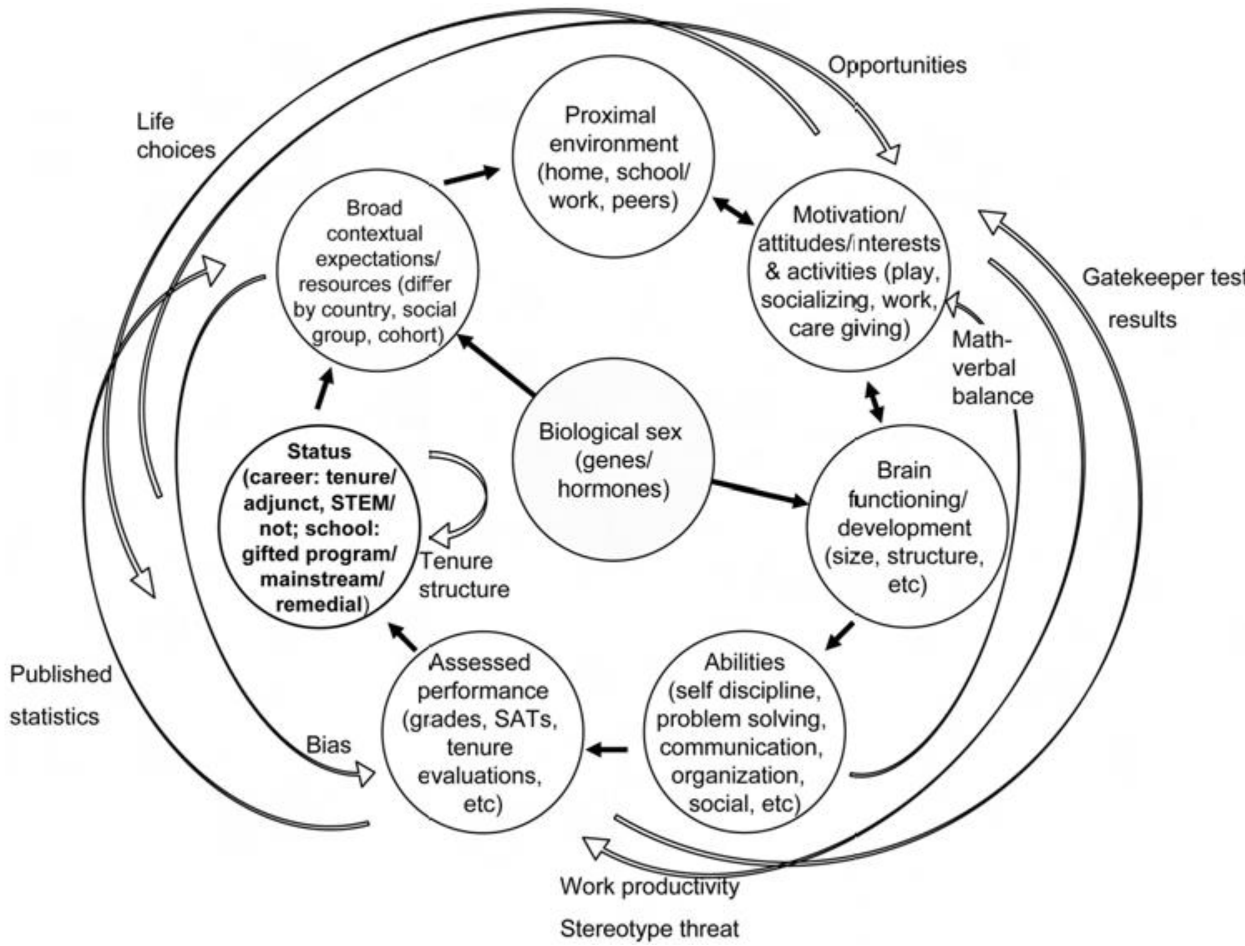

Figure 1 Factors affecting the under-representation of women in STEM fields[2]

Addressing the Problem

Since the first step in dealing with any problem is awareness, computer science and computer engineering programs at the University of Tennessee at Chattanooga include awareness of the gender gap in its curriculum in the required course CPSC 3610, "Ethical and Social Issues in

Computing." The course uses readings and discussions of classic and current ethical theories, as well as current news coverage related to computer issues. The goal is to inform, explore, and shape student attitudes toward state-of-the-art ethical issues which arise in computer professions. One of the course outcomes which is regularly assessed is awareness of complex social issues such as the digital divide and the associated gender gap in computer professions.

Several strategies are have been used to cover this course material. The first was the standard readings and lectures on the gender gap in STEM fields. However, this did not lend itself well to assessment of the student awareness as an outcome, as reading and listening to lectures are not quantifiable.

The next approach tried was an assignment using an Implicit Association Test to gauge student attitudes toward the gender and science. This assignment, detailed in an earlier paper,[1] asked students to read a relevant chapter of the course text, then to write a paragraph on why they think that there are so few women in engineering, the sciences, computer sciences, etc., paying special attention to whether they think there is any bias involved. Next, the students were to complete the Harvard Gender-Science Implicit Association Test (IAT). Finally, students were then to write their reactions to the Implicit Association Test results, addressing whether it was what they had expected or not. A significant number of studies since the first publication of the IAT methodology in 1998 have indicated the efficacy of Implicit Association Tests in capturing underlying attitudes, resistance to faking (e.g., participants deliberately manipulating scores), and repeatability of results. Additionally, a review of IAT studies indicates that for topics of social sensitivity (e.g., racial or gender issues), the validity of IAT measures was "relatively high" compared to the attitudes self-reported by participants. [5]

The expectation was that current students in the course would *believe* themselves to be completely unbiased in regard to gender and scientific fields, but would discover that they had a slightly greater bias than expected. The remainder of the assignment would then allow students to reflect on their previously unrecognized biases, and give opportunity for growth of awareness of gender bias in the current profession.

However, the results of this assignment were not as expected. Not only did the students in CPSC 3610 demonstrate a higher automatic association of men with science than the general population results cited by Harvard, [1] the students' written reflections were troubling. Rather than being surprised or concerned by the possible bias demonstrated by the IAT, more than half of the students in the class regarded this association of men with science as normal and expected. Student comments, cited anonymously to protect student privacy, included, "Girls just aren't interested in stuff like computers," "Women's brains can't handle the advanced math—it's a right brain, left brain thing," and "Women are better at nurturing than at technical things." Reasons given for this association were similarly disturbing: "Engineering has been, and always be [sic], a male-dominated field," and "It's nothing to do with societal bias—it's how girls are raised." This last would certainly raise the question as to whether how a society raises its children is not the ultimate expression of societal bias.

Student views on prospects of women's success in the professional world also demonstrated unconscious bias One student wrote that, "[One] reason that a woman would have a hard time getting [into] and progressing through an engineering or computer science career is that sometimes men have too much pride. There are men who would not tolerate knowing that a woman could do a better job." Another gave as his reason for few women in engineering as related fields as, "...women usually draws [sic] maximum benefits from their employers. If employers do not want to give a lot of benefits to an employee, they would most likely hire a male. I do not really believe there is any bias involved with this because the company just does not want to spend extra money on benefits." The students' comments were particularly surprising given that 40% of the faculty of the Computer Science and Engineering Department is female, giving the students ample opportunity to observe successful females in computer fields.

The IAT assignment's failure to raise the awareness of students of issues related to the gender gap made a new approach necessary. As part of a learning community investigating possible uses of Problem Based Learning in the curriculum at the University of Tennessee at Chattanooga, the author began to develop a more in-depth, team-based assignment to address the topic in a different modality.

Problem Based Learning

Problem Based Learning is a learner-centered educational approach, which shifts the focus of education to empowered students conducting self-directed learning. In this methodology, the "...learner is mentored and encouraged to conduct research, integrate what is learned, and apply that learning to develop a viable solution to an ill-defined problem." [6] Problem Based Learning has been in used in medical education in the U.S. for more than thirty years, and has been adopted by many other disciplines, including engineering. Some characteristics of PBL are

- Students ...have the responsibility for their own learning.
- Problems ... must be ill-structured and allow for free inquiry.
- Collaboration is essential.
- What students learn during their self-directed learning must be applied back to the problem with reanalysis and resolution.
- A closing analysis of what has been learned from work with the problem and a discussion of what concepts and principles have been learned are essential.
- Self and peer assessment should be carried out at the completion of each problem ....[6]

The problem of under-representation of women in technical fields fits the criteria of PBL, as it is both complex and ill-defined. Further, the many aspects of the problem require multiple avenues of research and would necessitate collaboration. Another essential aspect of PBL is that the assignments not be prescriptive—some ambiguity must be incorporated to allow students scope for creativity and for personalized approaches to solving the problem.

The PBL Assignment

The PBL assignment, first used in the spring semester 2014, included multiple parts: a preliminary assignment to gauge student attitudes before the team project, a three-week team project based on Problem-Based Learning, a student rating of team members, and a follow-up assignment to assess whether student attitudes had been changed by the team experience.

The initial assignment, given as a diagnostic, was the IAT assignment discussed in the "Addressing the Problem" section of this paper. After completing the initial assignment, the students were divided into teams of four or five and given the team assignment as follows:

> Now that you have done a baseline assignment to determine your initial thoughts on the Gender Gap in Computer Science, Engineering, and Science, you will be investigating this issue in groups of 4 or 5.
>
> Your goal is to determine
>
> - Whether the Gender Gap in technical fields is really a problem;
> - If so,
>   - Are we ethically compelled to address it?
>   - How?
>
> You should also address possible causes for under-representation.
>
> Your research should include, but is not limited to,
>
> - Demographics, government studies, social science studies, etc.;
> - Interviews with local businesses and women currently in technical fields;
> - Relevant current events.
>
> Each group will give an oral presentation of your results in three weeks.
>
> Your individual grade will be based on the inclusion of all required materials, your classmates' evaluation of your team's content and presentation, and your team's assessment of your personal contribution to the project.

The 20 minute presentations were graded based on inclusion of required materials, originality, whether the presentation made the audience think, whether conclusions matched evidence, presentation mechanics, and proper referencing. Individual student grades consisted of a possible total of 50 points: 40 points based on the work of the team, and 10 points from the team's rating of the student work.

Following completion of the team project and presentation, each team member was rated by his or her team based on participation, contribution, leadership, and timeliness of contributions. Each student was also asked to identify the one person, other than him or herself, who was most critical to the success of the project, and why. Students were also asked to discuss whether the team presentation represented their individual viewpoints.

As a follow-up to the team project, each student was asked to write a discussion of the following questions:

> What is the most interesting (and/or transformative) thing that you discovered in researching your own team's project?

What was the most interesting (and/or transformative) thing that you heard in one of the other team's presentations?
What was the item (in your project or another team's) that surprised you the most?
What was the possible solution to the gender gap that you believe to be the most promising? Why?
Based on your ethical viewpoint (rather than just your opinion), are we ethically compelled to address the gender gap?
Has this project changed your views on the gender gap at all, and if so, how?

The Results

The first implementation of this assignment in Spring 2014 was in a single class of 22 male and 4 female students. The group results in this initial assignment were mixed. Some groups were much more thorough than others in gathering information, particularly in the case of interviews with women in industry and academia. As the interviews seemed to have the most effect on student attitudes, it is unfortunate that not all completed this part of the assignment. At the end of the project, all groups concluded in their presentations that the gender gap was a problem that should be dealt with, but some used sexist language or stereotypes in their presentations. For example, one group stated in its presentation that "a woman must have invented the WII, because it's just so cute." Others made broad claims, e.g., about what men or women "prefer," without providing references or justification.

Individual results on the follow-up assignment showed more progress. After the project, most students felt that the Gender Gap was a problem that needs to be addressed, in a higher proportion than before the assignment: 53% before the project, and 72% after. In the written reflections, the comments frequently began "I didn't realize…" or "This really opened my eyes…," particularly in reaction to talking with women in STEM fields. The interviews that male students conducted with their female classmates were particularly effective. The male students were astonished that female students seemed to take discrimination and bias against women as an every-day occurrence.

The students suggested a variety of solutions to the gender gap, including educational programs through schools and through organizations such as the Girl and Boy Scouts. However, the most common solutions suggested were early intervention to engage girls in play relevant to STEM fields. The potential value of this approach was underscored by a visit the author made to her daughter's second grade classroom. The second graders in this good school district stated that there are some kinds of engineering that are only for men and boys. The young age of these students indicates that children are acquiring stereotypes very early; perhaps providing STEM-related play, also at a very young age, could counter these stereotypes. However, STEM-related play could, itself, prove problematic.

There are some toys related to STEM fields which are geared primarily toward girls, such as GoldiBlox. GoldiBlox is a series of construction toys, designed by a female mechanical engineer, which combines building tools with story-telling activities to attempt to engage girls in STEM play and capture girls' imaginations. According the product website, the "goal is to get girls building."[7] In addition to the gears, hinges, levers, pulleys, etc., currently included in the product line, plans call for future additions of motors, circuits, and coding, broadening the spectrum of engineering topics introduced through this “girl-friendly” line of toys. This product, however, is in sharp contrast to the recent controversy regarding Mattel’s “Computer Engineer Barbie.”

The release of Computer Engineer Barbie in 2010 was greeted with a great deal of optimism. Nora Lin, who was president of the Society of Women Engineers at the time of the product release, is quoted as saying, "All the girls who imagine their futures through Barbie will learn that engineers -- like girls -- are free to explore infinite possibilities, limited only by their imagination."[8] However, a book written to accompany the doll, *Barbie: I Can Be A Computer Engineer,* depicted Barbie as dependent on male classmates to write code for her and remove the viruses she infected not only her own, but her sister’s, computer with, and taking credit for the men’s work, while triumphantly proclaiming, “I can be a computer engineer!” The blatant sexism in the book caused such a furor on the internet that it was pulled from the inventories of Amazon, RandomHouse Kids, and Barnes and Noble in November 2014, and prompted an apology from Mattel.[9] Thus, even toys which are meant to encourage girls to explore careers in STEM areas can perpetuate stereotypes.

Concluding Thoughts

The gender gap in STEM fields in general is a prevalent problem and one which time alone will not solve, at least in the case of computer science, in which the percentage of women continues to decline.[3] As a first step in changing attitudes, the author has used a variety of approaches to raise student awareness of the issues and implications of the gender gap as part of a computer ethics course. The problem-based learning approach described here is a work in progress, and much remains to be done. Although the results from a single class in a single semester cannot provide any definitive results, individual results appear promising. The approach will be repeated and refined in subsequent semesters, and additional data collected to measure the efficacy of this approach in affecting students’ attitudes toward women and STEM.

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