GENDER DIFFERENCES IN CONFIDENCE LEVELS, GROUP INTERACTIONS, AND FEELINGS ABOUT COMPETITION IN AN INTRODUCTORY ROBOTICS COURSE

Elissa Milto[1], Chris Rogers[2], and Merredith Portsmore[3]

Abstract *¾ Classroom environment influences each student's educational experience. The aim of this classroom evaluation was to gain a better understanding of how each gender functions in an introductory robotics class, where LEGOs and ROBOLAB were used as a tool to teach engineering principles and basic robotics concepts. A better understanding of how each gender performs in reaction to the classroom setup will hopefully lead to the development of a learning environment that is mutually beneficial to each gender. The course, a general freshman introduction to engineering, targeted for this evaluation required students to complete robotic challenges while working within groups and participating in design competitions. The present evaluation explored gender differences in self-confidence levels related to robotic tasks, feelings toward competitions as a component of the course, and differences in the way males and females interact within groups. Assessment was conducted through interviews, observations, and written questionnaires. Competency in robotics activities was found to be similar although males were found to be more confident of their own abilities. Both genders felt the competitions were enjoyable and integral to the atmosphere of the class. Males in the class took the competitions more seriously than did the females. Building and programming robots were thought to be their greatest areas of learning by the women. Males, on the other hand, cited working in groups and learning to compromise as the areas where they made the greatest improvements.*

Index Terms ¾ Competition, confidence, engineering, gender differences, robotics

INTRODUCTION

The present survey aims to explore the differences between twenty-four men and women (17 men and 7 women) enrolled in an introductory engineering class. Targeted behaviors were those relating to confidence and performance levels in building and programming robots, feelings toward competitions, and interactions within groups.

A long precedent of inequity for genders in science classrooms exists [1]. Reference [1] has also found that teachers, texts, and class format "perpetuate these inequalities". Traditional science classrooms are not structured to interest females as much as males [2]. Boys tend to be more active participants in discussions and have a higher level of active manipulation [3]. Boys also have more experience and interest in the physical sciences while girls are more comfortable in biological sciences [4, 5]. Additional research [5] supports the assertion that girls are, in fact, interested in science, but are given fewer opportunities for exposure and success in science. One reason that gender differences exist, allowing boys more exposure, is that boys gain additional experience in physical science through out-of-class encounters [3]. Research [6] found the existence of a positive correlation between out-of-school science experience and positive attitudes toward science. Boys' experiences lead them to achieve in science while girls' lack of experience affects their confidence and achievement in physical science tasks. Although these differences do not necessarily correlate to lower science and engineering abilities, it does affect girls' achievement in science tasks. It is no wonder that girls have less positive attitudes toward science than do boys. Since attitude is a strong predictor of scientific achievement, girls' scientific achievements lag behind boys [3].

These differences in attitude and achievement also affect female interaction when working within groups. Females feel less confident than their male counterparts and may be less assertive. Research suggests that females often feel their comments are incorrect and that have little input to offer groups [1]. This behavior is especially true for groups comprised of both genders. Females prefer to work in same-sex lab groups [1]. Perhaps this is because females' lower confidence combined with boys' desire to control scientific activities lowers females' interest and involvement in physical, even leading to feelings of alienation in extreme cases.

Another factor that may influence females' behavior when involved in engineering tasks is the introduction of competition. Females traditionally prefer cooperative modes of learning rather than competitions [5]. Research suggests that females tend to be overshadowed by competition while males flourish in competitive settings. It is the attempt to identify and better understand these differences between males and females that fuel the present survey.

[1] Elissa Milto, Tufts University, Center For Engineering Educational Outreach, e_milto@yahoo.com
[2] Chris Rogers, Tufts University, chris.rogers@tufts.edu
[3] Merredith Portsmore, Tufts University, mportsmo@emerald.tufts.edu

Class Set-Up

EN 10 is an introductory mechanical engineering class that teaches basic robotics. LEGOs and ROBOLAB, a programming language written using LabVIEW, were used as a tool to teach robotics. Robots were built with LEGOs and programmed with ROBOLAB. The teachers were a female and a male that had previously taught the class.

Class met twice a week for nine weeks. On Monday, classes were conducted in a lecture format. Assignments were given on Wednesday and due the following Wednesday. Students worked outside of class to complete their projects and presented them during robotic competitions held during Wednesday classes. Students worked within groups of two during the first few competitions and groups of four during the last two competitions. Even though students' performance in the competitions was part of their grades, the instructors tried to keep the atmosphere relaxed and friendly. All students were encouraged to clap after each group's robotic presentation. No team or robot was declared the best and ranking of robots was not announced unless the goal of the competition was a function of time. Grades were dependent on one test, class participation, class attendance, and success of robots during the competitions.

Subjects

The twenty-four students enrolled in EN 10 participated in the study. All students voluntarily took the course. The class was comprised of 16 males and 8 females. Most students were freshmen (16), but sophomores (1), juniors, (1), and seniors (5) were also present.

MATERIALS AND PROCEDURES

Written Questionnaire

Two written questionnaires were given to students as pre and post-tests (Appendix A). Both were given during class time on a lecture day. The pre-test was given after students had completed one robotic assignment. The post-test was given on the last day of class.

The pre-test included questions pertaining to students' backgrounds. It was used to assess prior knowledge and experience related to programming, building, and the design process. It also served to establish a baseline for assessing students' confidence and performance levels in building and programming. The post-test was designed to assess knowledge gained, changes in confidence levels, and individual impressions of working in groups. Questions relating to confidence levels elicited quantitative data using a Likert Scale with four choices.

Observations

I. In-class Observations

Four groups of two were chosen for observation based on the genders of group members (See Table I). Observation took place as students built during a Wednesday class. Students did not know what the building challenge would be before the beginning of class. They were given approximately an hour to design, build, and program their robots.

Observations focused on task division, student interaction, method of design choice, and confidence displayed by students. The observer spent an equal amount of time with each group. Questions asked were not pre-scripted, but asked in response to actions or discussion of each group. Observation data was written down as the observations took place.

TABLE I

OBSERVATION GROUPS BY GENDER AND CLASS

Group	Gender	Class
1	2 females	2 freshmen
2	1 male/1 female	2 seniors
3	2 males	2 freshmen
4	1 female/1male	senior/freshman

II. Project Observations

Observation of one group of four (a female senior, a male junior, a freshman female, and a freshman male) was also conducted out of class while students were building for two design competitions. The observer, a female graduate student, also participated as part of the group. The group met six times. Focus of observations was the same as the in-class observations.

Interviews

Individual interviews were conducted with twenty-three class members (See Appendix B). Interview questions were open-ended, focusing on students' feelings about using ROBOLAB and LEGOs, working within groups, and students' confidence levels. There was no maximum amount of time allotted per question. Students were required to participate in the interviews as part of their test grade.

RESULTS

Student Background

All students voluntarily enrolled in the course, although five students said they chose the course due to degree requirements or because the class fit into their schedule. In general, males had more programming and LEGO experience. Fourteen students are declared or planning to declare their major as engineering. Six students were liberal arts majors and two students were undeclared.

Confidence Levels

Females scored lower in confidence of their robotic building and programming abilities than did the males (See Figures I & II). Women's confidence pre-test average scores were 0.43 in building and 0.57 in programming. Males' average scores were 1.87 in building and 2.1 in programming. All scores were out of three points.

Confidence levels for men and women increased during the class (See Figures I & II). Women's average confidence building score increased forty-eight percent on the post-test to 1.86. The average female programming score rose thirty-three percent to 1.57. The men's confidence building scores increased eighteen percent to an average of 2.4 and the programming score rose fourteen percent to an average of 2.53. When asked during the interview, only one student said that he did not feel more confident of his building skills. Five male students said that they were not more confident of their programming skills at the end of the class. Two of the five were computer science majors who had significant programming experience prior to the class.

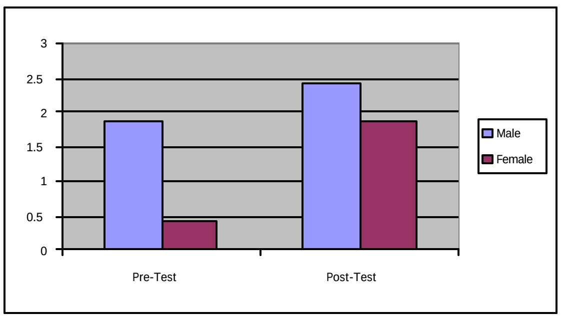


FIGURE I
PROGRAMMING CONFIDENCE

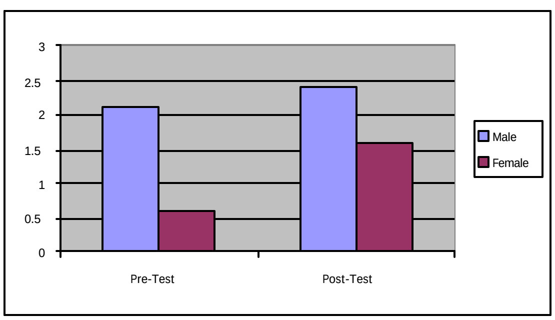


FIGURE II
BUILDING CONFIDENCE

During the interviews, women verbally expressed feelings of self-doubt and a lack of confidence in their building and programming abilities. Three females said that they were not very good at building or programming. They talked about "second guessing" themselves, assuming the males had better ideas and were more adept at building and programming. Even a female senior who was very verbal in expressing her ideas felt she was not a good builder or programmer when compared to other class members. When asked what her greatest strength in the class, one freshman said that she did not have any. The males did not voice the same perception of their own abilities. They generally felt their ideas were as good as or better than the other members of their group. Males that worked within groups of four males described their process of choosing ideas. All members constructed models of their ideas and presented them, trying to prove why their design was the best.

Performance

Building performance was assessed by two means. The first was a question on the questionnaires asking the students to draw a design for a bumper car and label its parts. The second way performance was assessed was by qualitatively comparing the robots students brought to class. There was found to be no significant difference in building performance between men and women.

Programming performance was assessed by two questions on the questionnaires. Students were asked to name and explain the function of eight ROBOLAB icons. The second means of assessing programming required students to unscramble a program for the bumper car that they were to design. Men performed somewhat better on the pre-test in both tasks (Icons: M 58% vs. F 56%; Scrambled Program: M 67% vs. F 60%), but on the post-test women matched the males scrambled program score of 90% and exceed their average Icon score of 79% with an average score of 85% (See Figure III).

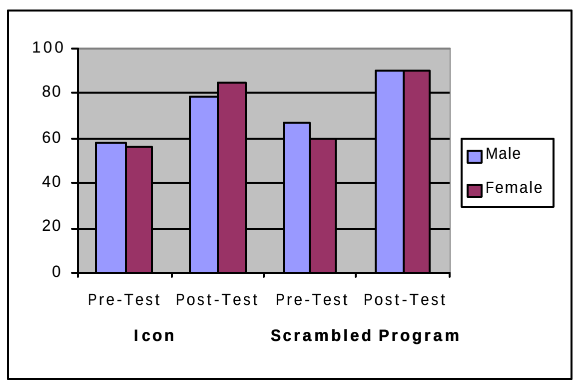


FIGURE III
PROGRAMMING PERFORMANCE

Group Interactions

Results related to group interactions were taken from the questionnaire, interviews, and observations. Both genders found benefits and drawbacks from working within groups. Among the benefits named by both groups were building on each others ideas, splitting tasks, completing work more quickly, and drawing on each others strengths. Drawbacks included finding a time all members could meet, having one group member change the robot without consulting other group members, and having to communicate ideas instead of just building on impulse.

Females believed differences did exist when working with groups that were all female versus groups that were mixed gender. The males expressed no perceived differences. One male in an all male group said that he "imagined that things would be different" working with a female, but could not verbalize what he thought the differences might be.

Two females felt that as women they struggled more with building than the males did. Three females mentioned that the males seemed more confident of their building abilities and "stepped forward" with ideas more often. A freshman female working with a junior male said that she was afraid to do things wrong and didn't do as much as she could have. No males thought that their building or programming skills were stronger because they were male. When asked what they had learned in the class, four of the males responded with answers that related to improving teamwork skills.

During the interviews students were asked how group members decided on designs for the robots. Based on observations, interviews and the questionnaires, it appeared that most groups regardless of genders, worked through the design problems using compromise to appease group members. One male/ one female group that was observed while building seemed to equally share tasks. The female member said that the male had conceptualized the basic idea, but when interacting they seemed equal in building on the beginning concept. The other male/female group did not appear to work as well together and argued while building. In both of the mixed-gender groups, both people had equal input to the design and building processes.

The two same-gender groups interacted differently. In the male/male group, one male had greater experience than his partner and did most of the work. He kept the robot in front of himself and worked. They rarely spoke. The members of the female/female group were not experienced LEGOs and did not immediately begin work on the challenge. They discussed what they were going to build for approximately ten minutes. Next, they split tasks. One student built and the other programmed. They rarely spoke unless they were asking for feedback from the other partner or trying to meld the building and programming into the final product.

With respect to working within groups of four, all students felt it was more difficult working with four people. Students reported more obvious gender differences when working with larger groups. Two females working with two males said that the males made major changes to the design after they had left and would not explain the changes. Groups of four males reported that they would all pitch their ideas for design to other group members. Some group members said that they would pick the best idea based on verbal descriptions or physical mock-ups. A member of another group that including a 2 male/2 female said they would pick an idea and try to incorporate at least one idea from each member to make all members happy.

Competitions

Students' perceptions of the competitions were gathered during individual interviews. Both males and females felt the competitions were a positive part of the class. Ten people (8M & 2F) said the competitions were their favorite part of the class. Competitions, rules for competitions, and grading criteria were described as enjoyable and fair by both genders. They described competitions as "fun". Two females felt that "some students took the competitions too seriously". None of the females mentioned that they wanted to know how their group's robots compared to others'.

Two males felt that the "competitions were not competitive enough". Two males did not feel that the implementation of competitions was fair because students were able to fix their robots mid-competition. The lack of specific guidelines for the competitions was a point that some males wish had been clearer. Three males mentioned that they wish they knew how everyone else did or where they ranked in the competitions.

One question in the interview probed the relationship between competitions and the design of robots brought to the competition. Students were asked if the work done (either time spent or design implemented) on robots was influenced because they would have to compete. Seven females said that knowing they would have to compete did not influence their final designs. Two females said that they just wanted their robot to work in class. Nine males said that their design was influenced by the design competitions and the competitions served as motivation to work harder. They admitted that they spent more time on their robots because they were going to compete. One freshman male said, "I wanted to prove myself". Another said that the competitions were very stressful and he "wanted to beat everyone else". A freshman male said that he spent more time fine-tuning his groups robot than if he would have if there had been no competitions.

DISCUSSION

Females felt less confident of their robotic abilities than did males, but their performance in building and programming did not match the difference between genders in confidence levels. Since confidence levels in both genders increased during the span of the class, it can be inferred that increased confidence is a by-product of increased experience and improved building and programming abilities. Females may have come closer to males' confidence scores if they had the prior experience possessed by most of the males. This finding supports the importance of exposing females to hands-on manipulatives.

Female's lack of experience also appeared to manifest itself with some females in the form of being less assertive within groups than males. Although, this could be partly a personality trait, using manipulatives to introduce engineering and science in high school or elementary school, would balance the experiences that students have as a result of males spending time doing more science related activities outside of class. The same rationale could be applied to introducing engineering. If females felt more comfortable with engineering related topics and hands-on manipulatives, perhaps more females would enter the field.

Some results from the present study could be affected because the students in the class voluntarily enrolled. Females taking the class may not exemplify average females of their age because they might be more comfortable with science and engineering than other females. The sample size of this study was relatively small. Both these factors could confound the generalizability of the results. Another confounding factor could be that groups were comprised of undergraduate students from all four classes. Older students could be intimidating to freshmen. If this was the case, students in groups could have been responding to age rather than gender.

It does seem possible that both genders could benefit from working within groups at earlier ages. Females perceived a difference in working with males, but the males did not mention that gender introduced any differences into groups. Males did mention differences in response to questions that did not specifically ask if differences existed, saying that women compromise more. This suggests that there was some difference and the males were either not aware of how such a difference would affect group interactions or they were afraid to mention any perceived differences perhaps because the interviewer was female. Allowing students to work in mixed-gender groups might help males realize there is a difference between the experiences they and females have. Since it seems that effective group interactions are learned through experience, it is a difficult question to decide when the gender make-up should be structured with mixed genders and yet structure groups so that men and women can equally participate and feel empowered by the experience.

Working within groups on design projects combined with the earlier introduction of engineering would help women become more confident of their abilities and comfortable being assertive with male group members. Mixed-gender group work would also allow males to enter into situations in which they need to compromise. The overall result would be groups that benefited from the ideas and experience of all members.

With respect to competitions, the present study suggests that it is not competition alone that negatively affects females perceptions, but the level of competitiveness. All females in the class enjoyed the competitions. Negative feelings surfaced when they felt other members (males) of the class were taking the competitions too seriously. Conversely, males seemed to enjoy competitions more when they were more cutthroat. One male even said that if he took the class again he would like to make robots that destroyed the other robots.

FUTURE DIRECTIONS

When arranging groups, the teacher could assign group members such that students would be paired with those who have equal experience and exposure to LEGOs and computer programming. This would negate the chance of students reacting to age or feelings of low confidence because their partner is more experienced.

Other factors may include the role and influence of the teacher(s) conducting the competitions. Future research may explore the role and influence of teachers in student's feelings toward competitions. This would narrow down what behaviors and feelings can be attributed to competitions verses reactions to the teacher(s).

Increasing the number of observations could strengthen validity of findings. Specific guidelines could be established so that the observer could conduct observations more consistently and quantitatively. This would allow researchers to further study the correlation between females' and males' confidence levels and their building and programming abilities.

Finally, conducting similar surveys in varying academic levels could strengthen findings of the present study. One problem with just using college students in this and future studies is that students have selected the class themselves. This self-selection could narrow the implications of the study to engineering students.

Students in higher-level college and graduate courses would presumably have equal experiences due to prerequisites. This would negate the influence of varying experience levels when exploring confidence levels and interactions. Using elementary students as subjects would allow researchers to explore their interactions, feelings, and performance abilities and compare findings with self-selecting older groups.

REFERENCES

[1] Guzzetti, B, & Williams, W, "Gender, text, and discussion: examining intellectual safety in the science classroom", *Journal of Research in Science Teaching*, 33, 1996, 5-20.

[2] Andre, T, Whigham, M, Hendrickson, A, & Chambers, S, "Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects", *Journal of Research in Science Teaching*, 36, 1999, 719-747.

[3] Javonovic, J, & King, S, "Boys and girls in the performance-based science classroom: who's doing the performing", *American Education Research Journal*, 35, 1998, 477-496.

[4] Baker, D, & Leary, R, "Letting girls speak out about science", *Journal of Research in Science Teaching*, 32, 1995, 3-27.

[5] Jones, G, "Gender differences in science competitions", *Science Education*, 75, 1991, 159-167.

[6] Rennie, L. (1987, July). "Out-of-school science: are gender differences related to subsequent attitudes and achievement in science?", In Daniels, J. & Kahle, J. (Eds.), Proceedings of the fourth girls into science and technology conference, July 1987, 8-15.

Appendix A

EN10 Pretest & Posttest*

Name: ___________________________
Class/Year of School: ___________________________
Intended Major: ________________________

1. Please complete the following chart, indicating which programming languages you know, your level of proficiency and how you acquired knowledge of the language.

	PROFICIENCY LEVEL (check *one*)			HOW YOU LEARNED THE LANGUAGE (check *all* that apply)		
PROGRAMMING LANGUAGE	Slight familiarity	Basic proficiency	Advanced proficiency	Took a class	Self taught	Other (describe)

2. How do you learn best about programming? (Check one)
   ❒ Organized instruction
   ❒ Teaching self
   ❒ Other (describe): ________________________

3. a) Do you usually use a ❒ PC ❒ Mac
   b) Are you comfortable using both platforms? ❒ Yes ❒ No

4. Have you participated in design competitions before? ❒ Yes ❒ No ❒ Unsure
   If so, where? (school, YMCA, etc.) _______________________
   Did you work: ❒Alone ❒With others

5. Describe (briefly) what you think the design process is.

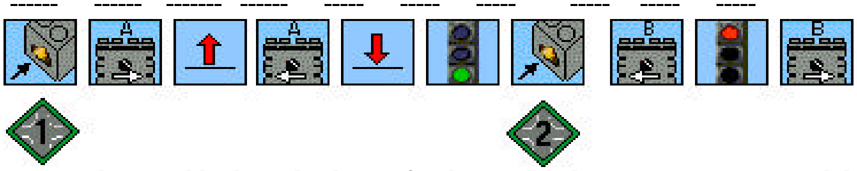
6. How would you divide tasks to complete a robotic design project?

7. Have you used Robolab before this class? ❒Yes ❒ No

8. Briefly describe what the following icons do or how they can be used.

9. a) Number the following icons in order to program a car to move around a room and drive away from the walls when it hits them. Number above the dotted line.

------ ------ ------- ------ ----- ----- ----- ----- ----- -----



b) Roughly draw the design for the car, labeling important parts and their functions.

10. How confident are you of your Robolab programming abilities?

❒Very confident
❒ Moderately confident
❒ Slightly confidence
❒ Not very confident

11. How confident are you of your building abilities?
❒Very confident
❒ Moderately confident
❒ Slightly confidence
❒ Not very confident

12. In your opinion, how applicable will what you learn using Robolab be to other computer programming?
❒Very confident
❒ Moderately confident
❒ Slightly confidence
❒ Not very confident

13. Describe one type of data you could measure with Robolab?

The following questions apply to the project that was due **last Wednesday, September 12th**.

14. How many times did you test your project before taking it to class?
❒ 0 ❒1-3 ❒4-7 ❒8-10 ❒more than 10

15. a) Did you change your design? ❒Yes ❒ No
b) If yes, how many times? ❒1-3 ❒4-7 ❒8-10 ❒more than 10
c) Did you change your program? ❒Yes ❒No
d) If yes, how many times? ❒1-3 ❒ 4-7 ❒8-10 ❒more than 10

16. a) Did you plan your design before starting to build? ❒Yes ❒No
b) If you planned before building, how did you plan? (check all that apply)
❒ In your head
❒ On paper
❒ By talking with your partner
❒ Other _________________

17. Did your program behave like you planned during the competition in class?
❒Yes ❒ Mostly ❒ No

18. Describe any benefits that you experienced related to having a partner:

19. Describe any drawbacks or challenges you experienced related to having a partner:

20. How did you divide tasks with your partner? In other words, who did what? There's no need to mention names.

* The posttest was identical to the pretest except for the omission of five questions. These questions (1-4 & 7 on the pretest) were used to determine students' computer and design experience prior to the class.

Appendix B
Individual Interview Questions

1. Why did you take this class?
2. Has it altered your concept of what engineering is or engineers do?
3. Has it altered your intended major?
4. What was your favorite part of the class?
5. What was your least favorite part of the class?
6. What do you feel that you learned in this class?
7. What would you like to see change if you took this class again?
8. How did you feel about Robolab as an interface? Was it presented in an effective manner? What would you change?
9. Do you feel more confident of your programming abilities than when you started the class?
10. Do you feel more confident of your building abilities?
11. Was building presented in an effective manner? What would you change?
12. Do you like the format of the class/the way it was taught?
13. How do you feel about the competitions as part of the grading process?
14. Was your final product/design affected knowing you would have to compete?
15. What was your biggest strength in this class?
16. What was your most prominent weakness?
17. How did you learn what the pieces did?
18. How do you think your group was affected by having # of females/# of males?
19. Would the way your group got along have been different if there had been (change the gender of group members)?