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Encouraging Women in CS 1: Interventional Inclusive Pedagogy in Computer Science

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Encouraging Women in CS 1: Interventional Inclusive Pedagogy in Computer Science

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ABSTRACT

The gender parity in the field of computer science (CS) is evident in education, workforce and research. This study, explores the introductory computer science class in an attempt to understand the low retention of women in CS. As means to encourage the retention of women in this class in the department of computer science at the University of Minnesota, Duluth, two interventions were applied to address the issue of retention of women in CS . These interventions were based on the research findings where women are more inclined to solve real world problems that can benefit mankind and that women are dependent on social networking and more inclined to share their feelings with others when compared to men. The interventions were executed by offering a Facebook discussion group among consented students in the introductory courses in addition to replacing the traditional assignments with real-life problems in Fall 2015. The participants were surveyed to examine the effect of the two interventions. Our findings concluded that building the online discussion platform and using more practical problems can potentially help increase women's interest in studying computer science. To track future research a feedback mechanism was developed that will aid in improving our approach.

CCS Concepts

K.3.1 [Computers and education]: General

General Terms

Human Factors

Keywords

Women in computing; use of social media to encourage retention of women; issues concerning women in computing; encouraging women in computing

1. INTRODUCTION

There is wide gender imbalance in the field of computer science (CS) field resulting in more men than women in various areas of the industry, academia and business [1, 2]. The female computer science students make less than 20% of the total undergraduate student population [1]. When it comes to graduate school only a fraction of these undergraduates is pursuing graduate school leading to fewer female students in graduate school are researching in computer science. This phenomenon is reflected in other computer science related fields such as computer engineering as well [2]. For example only 30% of women are employed in computer science. The ripple effect can be observed in making the situation even worst by creating a very small pool of positive female role models for women in CS [3, 4, 12]. This results in making it harder for women in CS to succeed, which only strengthens the stereotype that women are lacking in the fields of technology and science [2]. This stereotype is also associated with developing a lack of confidence among women in their goal to succeeding in CS career [5], and the further they go, the more insecure they feel. This anomaly only grows by indirectly forcing women in CS to quit CS due to the struggles they encounter. Some researchers have found female graduate students in CS to lack self-confidence when compared to men [5]. This stereotype also plays a role in pushing women away from CS at young ages [2]. This phenomenon is creating a vicious circle in which there will be fewer and fewer women studying and working in the CS field. Pedagogy plays an important role in addressing student engagement {16, 17, 18, 19, 20, 21, 22, 23, 24, 25]

There are numerous research studies in the understanding of encouraging women in CS and why women quit or stay away from CS department. The important factors in gender imbalance are recruitment of women in CS and once recruited, retention of these women in CS. After many continued efforts a small number of women are being recruited in CS only to lose some of them during their first years of undergraduate schooling.

It is imperative to find mechanisms to attract women in CS and understand why they are leaving CS [9]. It is also important to put in additional efforts to retain the women who have entered CS. After reviewing the literature, it is evident that retention and enrollment of women in CS is a major concern and the population of women in CS related fields is decreasing. Although enrollment and retention of women in CS is a problem, this paper only addresses the retention issue.

Although the gender imbalance is a global problem, in this paper we will use the case of the University of Minnesota, Duluth (UMD) to introduce the problem more specifically. And we look into the problem with the introductory courses [7, 10] in CS at UMD. Every computer science major student in UMD is required to take two large CS introductory courses, CS1511 (CS1) and CS1521 (CS2) in a sequence. Figure 1 and Figure 3 show the student distribution of men and women in CS 1511 and CS 1521 respectively. Figure 2 and Figure 4 show the DFW rates of men versus women in the CS 1511 and CS 1521 respectively.

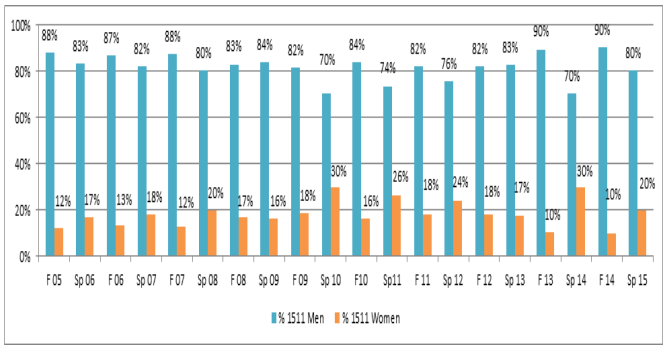

Figure 1. Total Enrollment of CS1511 (Men vs Women)

The 10 year data represented here is for the enrollment and the drop, fail, withdraw ratios (DFW) of these two courses (CS1511 and CS1521). It is clear from this data that the enrollment and the DFW rates are shockingly low. In CS1511, the ratio of women has never gone beyond 30%, and in Fall2013, (Fig 1) it hit rock bottom at a striking 10%. Although the DFW of women for CS1511 is almost similar to the DFW rates of men, we cannot neglect the fact that there were way more men than women in this class. Even in this situation, in Fall2010 (Fig 2), the DFW of women was as high as 50%. In the past twenty semesters of CS1521, 80% of the semesters had a female enrollment that was below 10% (Fig 3). The DFW was no better than the enrollment. The DFW for women has been over 50% for six out of the 20 semesters. In fact, in the fall of 2008, all of the female students dropped this class.

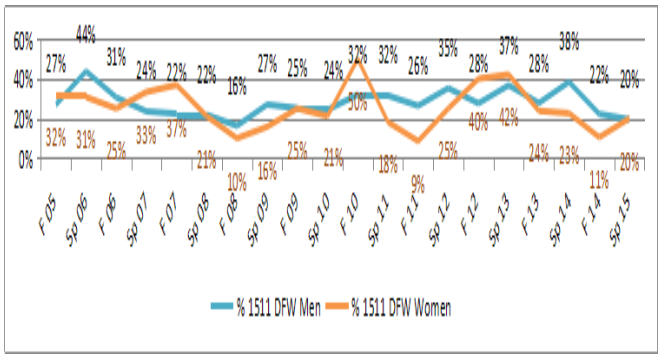

Figure 2. Total DFW of CS1511 (Men vs Women)

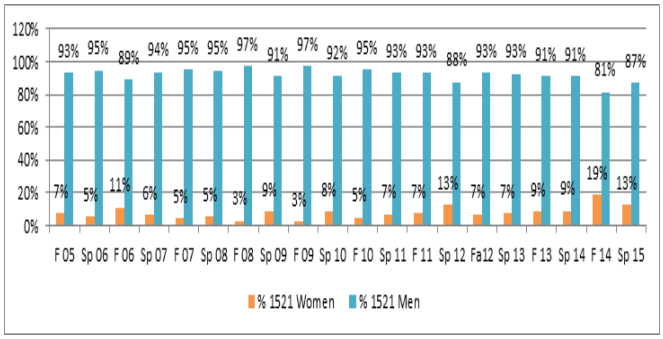

Figure 3. Total Enrollment of CS1521 (Men vs Women)

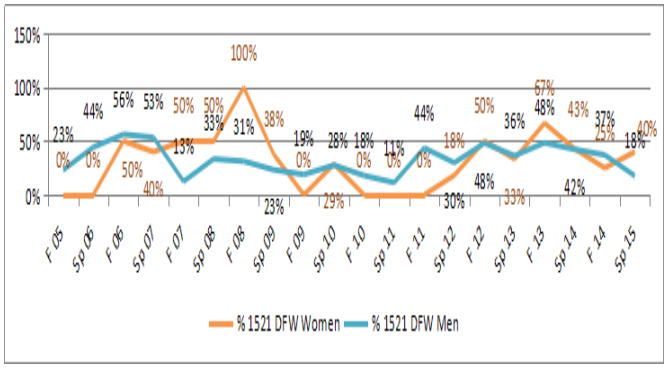

Figure 4. Total DFW of CS1521 (Men vs Women)

The CS 1511 corresponds to the computer science 1 (CS1) course and the CS 1521 corresponds to the computer science 2 (CS2) course of the introductory curriculum. These courses have received attention in with respect to retention in CS field. Two major concerns with respect to these courses are about the material taught and the failure rates, which are similar to the pattern observed in the CS1 and Cs2 at UMD [16].

2. METHOD

2.1 Research Question

The research question is: Can small interventions such as changing the problem statements and offering an avenue to socially interact increase the interests of women in computer science?

Hypothesis

Hypothesis 1: Engaging students via social media can offer an avenue to interact and help increase interest in CS [8, 11, 14, 16, 17, 18,19, 20].

Hypothesis 2: Women's interest in CS can be enhanced by replacing the traditional assignment with assignments that address problems that are closer to real life issues and that can benefit community [6].

2.2 Methodology Outline

From reading the literature, we learned that women prefer to solve more real world problems that can benefit humanity at large than solving abstract problems. We also learned from the literature that women prefer to be more social and interact and work well in teams. This project is based on these findings and attempts to develop a new approach grounded in research-based pedagogy. This new pedagogy involves two interventions to the traditional classroom teaching style- one, it replaces all the problems in the class with problems that are closely related to real problems and that benefit the community at large; two, it uses a social media platform that gives the students an opportunity to interact socially, discuss and share their thoughts and ideas on these problems.

In the fall semester of 2015 the above-mentioned interventions were applied to the CS1(*CS1511*) course at the University of Minnesota Duluth. The first intervention involved creating a Facebook discussion group [14, 25] with students willing to participate in this study intervention. The students were invited to a *closed Facebook group* named Free Talk Zone monitored by a student mentor, during which any of the group members were able to add new members to the group. Both men and women were invited to this group and the student mentor monitored the difference between the group discussion between women and men. This social platform offered students who were new to programming an avenue to communicate and explore programming techniques and learn from their peers. The topics of the discussion aimed at the implementation of weekly assignments and expanded towards news for upcoming computer science events in the nearby community and some other fun exercises related to the with the material covered in class (E.g. Some hard topics like pointers). A feedback mechanism was integrated into the group discussions so that the students could report how they perceived and addressed the problems in the computer science course they encountered. A survey, housed in Qualtrics was used as the feedback mechanism. In addition, we also worked with the instructor for CS1511 and changed some traditional assignments to projects that address real-life problems. The group ran since November 1st with eight initial members. By the end of the semester (Dec 18th), the number of group members doubled, including an addition of a graduate

teaching assistant who was also interested in encouraging women's interest in CS.

The student monitor played an important role in monitoring the homework discussions where the entire process of how students finish their project was tracked. Most of the time, the mechanism for solving the problems was not unique and other times different students suggested different solutions. This created an interesting dynamic in the discussions where we could see the collision of their ideas, which was a great motivation for the students and furthered their interest in the subject. The students were given the option to share their continued progress of their code until the day of submission. It was fascinating to observe the improvement in their understanding of the subject little by little as they built confidence and realized the power of computing.

2.3 Findings

Two interventions were applied in an introductory CS 1 course at the University of Minnesota Duluth. The findings indicated that projects with more practical topics encouraged students to discuss the topics, resulting in a conversation where the students started to share their thought processes. Due to the more practical nature of the projects, students seem to be understanding them better and seemed to apply the knowledge from class efficiently. And this allowed students to share their results even with their friends in majors that were not related to computer science. For example, we replaced project 7 with the one extracting popularity of names in the nation from an external file. Some women in our group located their friends' name in the list and told them how popular their names were. This would be a great motivation for students to study, as they could clearly see how their projects are related to their lives and has the potential to attract non CS students to the CS field.

The Figures attached are the screenshots from the discussion group to demonstrate our findings. The project 8 was used in these screen shots as an example. This project asked students to write a program to print out a string the user entered in reverse order. The first one (Fig 5) was the question raised by a group member according to the project. The second one (Fig 6) was from a communication about the solutions of Project 8, where three of the group members in this discussion had different solutions.

Figure 5. Question regarding the solution to a particular project by a group member

Figure 6. Group communication for the solution of a particular project

The shortcomings of the group discussions were examined, where discovered that the group participants were less inclined to discuss subjects other than the CS1511 course. This inclination reduced the number of potential discussions that could have happened.

Another drawback of the group discussion was more on the time span of the discussion ground. As the students in the CS1 are new to CS and to undergraduate school majority of them did not know each other and hence initiating discussions was a bit challenging. In addition, this was a very large class and the number of students was intimidating for them to interact. Besides the serious topics of CS, they were not that comfortable talking about their feelings and thoughts for the course they were engaged in. Some of them preferred to post their results on their friends group rather than the Free Talk Zone and they were also not comfortable discussing their code as a group.

The third issue that was detected was that, the additional exercises assigned to the group to improve their understanding of the material was not welcome by the students as they preferred to complete the work that was attached to a grade.

2.4 Recommendations for future study

Bearing in mind the observations and shortcomings of the interventions we plan to augment our interventions by ensuring the drawbacks observed were addressed. One recommendation is to have icebreaking games at the beginning to make the group members familiar with each other and to get the conversation going. Another recommendation is to explore other mechanisms to familiarize the students with each other so they feel comfortable to share their code and have a lively discussion on topics not only related to their course work but also other CS topics. This way, they will be more comfortable talking about their feelings in the group. Another recommendation is to reduce the number of restrictions on the topics of communication. This experiment was a trial and we gained some good insights on how to improve this study to create a larger impact on encouraging women in CS (as shown in Figure 7). Lastly, we are planning to invite the entire class of CS1511 to the discussion group in addition to introducing a rewarding mechanism to the discussions, so that more students will be likely to try those extra exercises. We intent to focus on encouraging women in the computer science by examining the performance of women and build a feedback mechanism that can continuously help improve our interventions.

Figure 7. Less serious topic with better feedback

3. RESULTS

At the end of the three weeks of the pilot study we surveyed the students who participated in the group discussions enquiring about their experience in the CS discussion group via Qualitrics. Figures 8, 9, 10, 11, and 12 are the answer distributions to some of the survey questions.

Figure 8 shows the answer distribution to the survey question - *what is the importance of communication and group work in computer science?* Figure 9 shows the answer distribution to the survey question - *I found students raising problems that were similar to the ones I was facing in completing my assignment*. Figure 10 shows the answer distribution to the survey question, *I got inspired by someone else's idea in the Facebook Discussion Group for my own assignment*. Figure 11 shows the answer distribution to the survey question - *did the group discussion group help you to learn CS1511 better or keep your interest in the course?* Figure 12 shows the answer distribution to the survey question - *assignments related to real-life problem will increase my interest in computer science.*

Ten students finished our survey. Five of them were in the computer science major, and one of them minor in computer science. 70% of the participants are female, while the rest of them are male. All the students participated are in their freshman or sophomore year, and 80% of them were freshmen. From the information gathered above, we can say that although the number of participants was not that large, the group being surveyed fitted the feature of the targeting group of our research, which was, females in the introductory stage of their study in computer science.

We also performed a qualitative analysis of the observations of the discussions, which revealed the importance of the role of the discussion facilitator and the motivation and supportive role this mentor plays. It is essential to have a vibrant discussion and a means to introduce the students to each other and familiarize with each other.

Ultimately, although there was no improvement in the DFW rates, the intervention of implementing a discussion group to facilitate communication among the students was achieved successfully via the Facebook group. An essential component of this study was the role of the mentor/group discussion monitor. It is critical to have a student who is passionate about encouraging women in CS to facilitate this group discussion to encourage conversation and a diversity in the discussion of topics.

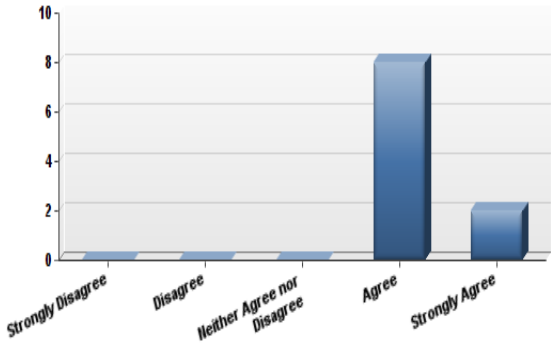

Figure 8. Answer distribution of the survey question: *"What is the importance of communication and group work in computer science."*

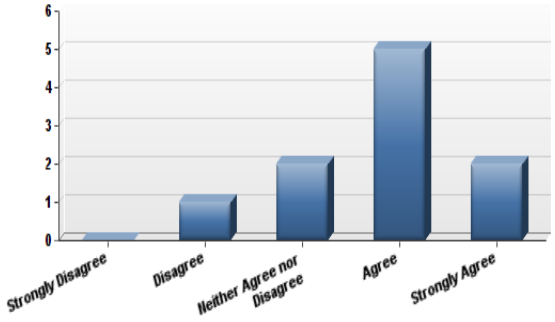

Figure 9. Answer distribution of the survey question: *"I found students raising problems that were similar to the ones I was facing in completing my assignment"*

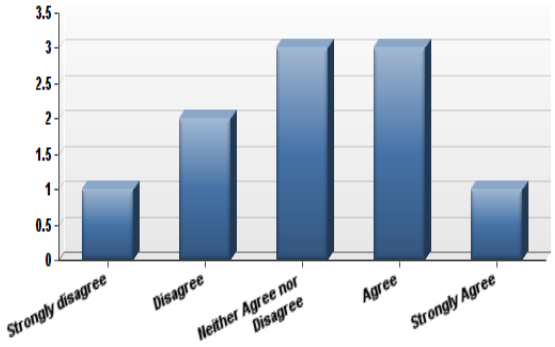

Figure 10. Answer distribution of the survey question: "*I got inspired by someone else's idea in the Facebook Discussion Group for my own assignment*"

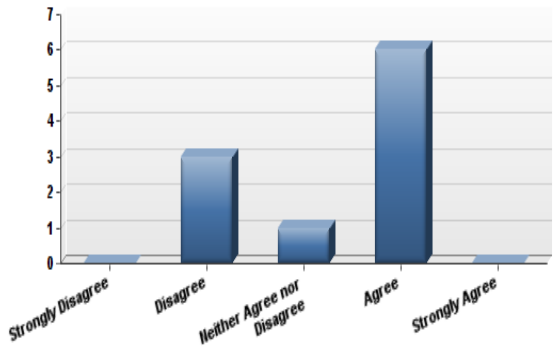

Figure 11. Answer distribution of the survey question: "*Did the group discussion group help you to learn CS1511 better or keep your interest in the course?*"

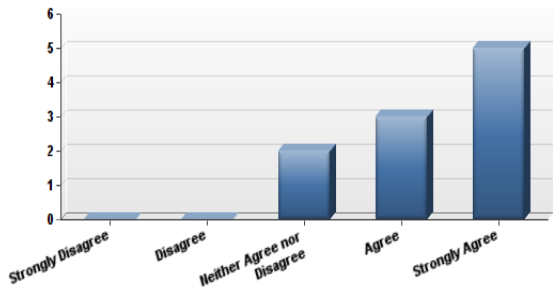

Figure 12. Answer Distribution of the survey question: "*Assignments related to real – world problems increase my interest in computer science*"

Hypothesis 1 is supported by the answer to the question, what is the importance of communication and group work in computer science (shown in Figure 8.). For this particular question, 80% of our participants chose 'Agree', and the rest 20% even chose 'Strongly Agree'. More specifically, for the content of the discussion group, 70% of our participants have found problems raised in the group by other students similar to the one themselves were facing (shown in Figure 9.). 40% of the participants stated that they got new inspiration from someone else's idea in the group (shown in Figure 10.). In addition, 60% of our participants agreed that the Facebook discussion group helps them learn CS1511 better and kept their interest in the computer science (shown in Figure 11.), while 10% of them stayed neutral and 30% disagreed. All of those answers listed above supports of the idea that our targeting students (mostly women) would like to share their feelings with others during their study process and social networking can be used as a tool helping them study.

Hypothesis 2 is supported according to the results we got. We found all of the students admitted the importance of the practical assignment (shown in Figure 12.). 50% of our participants strongly agreed with the idea that assignment related to real-life problem would increase their interest in computer science, for which 30% of our participants chose the option 'agree', and the rest of them stated neutral. This result reveals that our targeting group prefer homework based on real-life problem. As women are our targeting group, we are able to say the result we got supports Hypothesis 2 proposed above, which is, women are more inclined to solve real problems that can benefit our community.

4. CONCLUSIONS

We examined the literature to find out the reasons why women quit the CS field and emphasis was given to understanding the nature of women and what will help them succeed. Facebook was used a means to help students socialize and create a discussion group. This social platform offered students an opportunity to discuss, share and learn from each other topics related to the material covered in class each week. A closed group was created in Facebook with a female senior student playing the role of a mentor, mediator and guide who facilitated the group discussions. A wide range of topics were covered in these discussions. Teaching assistants (TA) in the department were invited to participate in the discussions and provided professional perspectives. Two interventions based on research pedagogies were designed to improve the women's interest in CS. One intervention was in the creation of a Facebook discussion group for students and the second intervention was in modifying the traditional assignments to problems related to real life issues.

The interventions were evaluated qualitatively as well as quantitatively in gauging their effectiveness as a new pedagogy. The qualitative analysis was performed by comparing the results of the pre-and-post interviews; and quantitative analysis was conducted by comparing the grades to prior years and administering surveys. This interventional experiment verified our hypothesis that women prefer a social atmosphere where they can interact and share their ideas to help increase their interest in CS. In addition, the hypothesis that women prefer solving problems related to real life issues was also verified. As the number of participants in the discussion group were small, the accuracy of the conclusion was not that high. We propose to increase the participation of students in the discussion group in the next trial. It will be beneficial to design and develop a new social networking platform that can be used in classrooms to encourage interaction will be our ultimate goal with an emphasis on student experiences in the CS study.

In an attempt to make the assignments as closely related to real life issues as possible will help increase female interest in CS.

In addition, it will be beneficial to understand the differences in instruction format in countries where there is little gender imbalance in the computing fields such as in India[15] and Malaysia [13]. The insights and knowledge gained from these explorations will also be integrated in the next round of intervention development to increase women in CS [25].

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