Sense of Belonging of Female Undergraduate Students in Introductory Computer Science Courses at University of Brasília in Brazil

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***Abstract*—Full Paper - The field of Computer Science (CS) has been of little interest to women straight out of high school when considering undergraduate majors in Brazil. At the University of Brasília, a top-ten university in Brazil, female undergraduate students account for less than 15% of the students in the Department of Computer Science. According to Stout and Blaney, a sense of intellectual belonging is "the sense that one is believed to be a competent member of the community". This perception may be especially challenging for members of underrepresented minority groups, such as female undergraduate students in CS majors. In this context, this paper addresses two research questions: i) "How does the intellectual sense of belonging of female students compare to the male students' in introduction to computer science courses?"; ii) Is it similar for female undergraduate students in both CS and non-CS majors?". We devised a questionnaire for students in the introduction to computer science courses for different majors. We analyzed the responses and, in general, introductory programming courses are challenging for all students, however, female students feel worse about their computing competencies than male ones.**

***Index Terms*—Women, Computing, sense of belonging, Computer Science**

I. Introduction

According to Stout and Blaney in [1] a sense of intellectual belonging is "the sense that one is believed to be a competent member of the community". The sense of belonging is also called ambient belonging [2], or feeling of belongingness [5].

Retention in Computer Science (CS) majors has been a challenge [4], and the numbers are even worse when it comes to students from underrepresented groups, such as women, since CS undergraduate students are predominantly male. Veilleux et al. in [3] emphasize the importance of a sense of belonging, finding that a strong sense of belonging in computing helps students to persevere, even when they have doubts about their skills in the subject. This feeling is especially challenging for female undergraduate students in CS majors, as presented in [1] [2] [5] [6] [7] [8] [9].

In this context, this paper addresses two research questions: i) How is the intellectual sense of belonging of the female students compared to the male students in the Introduction to CS courses?; ii) Is it similar for female undergraduate students in both CS and non-CS majors?. We devised a questionnaire in the first academic semester in 2020, with 20 questions for students in the introduction to CS course for different majors at one of the top 10 Brazilian universities. We chose this because it is the first programming course and has been identified as a pivotal point in the retention of undergraduate students in computer science majors [12] [13] [14] [15] [16] [17]. We analyzed the responses and have presented them in this paper.

Our paper is composed of the followed Sections: Section II presents a background about women in Computing; Section III describes the process applied in this paper; Section IV presents the demographic of the respondents; Section V presents the answers from the student survey; Section VI presents an analysis of the findings; Section VII discusses the study limitations; and Section VIII presents the conclusions and future work.

II. Women in Computing

Gender diversity in computing has been addressed in papers since the late 1980s [18] and still confirmed in recent articles [19] [20].

The importance of studies and interventions about women in Computing is accentuated by the requirement of innovative and inclusive work forces in computing companies, reinforcing that the gender gap is not an issue of academic relevance only [19] [20]. For example, Stout et al. [21] study the influence

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of stereotypes on women and men's science careers, while Mercier et al. [22] relates the gendered media representations to women's interest in computer science.

Stereotypes and media representations can affect the understanding of school students and [23] employs interviews, drawings and surveys to examine the middle school students' perception of knowledgeable computer users and their self-perception as a computer-type professional. Among the stereotypes of a computer professional identified in these results are: is male (89%) and wears glasses (94%).

Examples of stereotype misconceptions towards female computer scientists are mostly related to physical appearance and personality type, as shown by [24], in which research was conducted with high school students in Scotland.

Recent studies [25] show that the gender gap in CS Bachelor programs has become worse in the United States (US), with the ratio of graduate women going from 40% in 1984 to only 20% in 2006. In 2013 and 2014, data published in [26] shows that only 14.7% of CS Bachelor degrees were granted to women. The Annual Report of the National Center for Women & Technology [27] shows an increase in the numbers of women in Computer and Information Sciences Degrees, about 20.9% and the rate of growth is slowly increasing. However, the gender gap persistently remains.

This reality is not limited to the U.S., as can be seen in studies all over the world. In Greece, for example, [28] reports that females were less numerous than males in all grades of tertiary-level education.

Also in Greece, another study [29] analyzed students of both genders regarding their intentions and motivation for pursuing academic computer science studies. A total of 358 high school students' responses were examined using descriptive statistics, principal component analysis and analysis of variance. This study looked into several factors, such as the influences of family and academic environment on their career choices, their perception of a professional career in CS, and their self-efficacy beliefs regarding computers. Among its findings, the study showed that one of the main factors discouraging students from CS studies is the absence of computers, both at home and in school, which creates a lack of exposure to and use of computers.

A study in Australia [30] investigated potential aspects associated with the low percentage of females taking part in the education pathways leading to ICT (Information and Communication Technology) occupations. The study took into account data from 1,453 girls in their senior year at high school for a duration of three years. The survey presented to these girls contained binary options, such as "I am very interested in computers", and "I am not interested in computers", and the resulting data was analyzed using Mann-Whitney U test comparison, means, and non-parametric statistics. Two factors were identified as being relevant to the women's avoidance of ICT professions: the perception that the subject is boring and an intense dislike of computers.

A comparable situation is shown by the Higher Education Census data in Brazil, which is analyzed in a study focusing from year 2000 to year 2013 [31]: the number of female graduates decreased by 8% that while during the same period the number of male graduates increased by 98%. Recent data [32] shows that the number of women graduating in CS-related majors in Brazil was roughly 13% in 2019, with an increasing number of male graduates and a steady number of female graduates.

Several recent works focus on studying the role of social support and opportunities to use computers in the girls' decision to envision a career in computing. A large study presented in 2019 [33] examined factors that can make an impact on high-school girls' choice to enroll and continue in CS-related majors: social support came up as one of the main factors. This result is in accord with [34] and [35], which emphasize summer camp as providing distinctive opportunities to include computing lessons for young women. Finally, it is important to note that although the experience of using computers is relevant and necessary, it is not, on its own, sufficient, as stated by [36]. Social support still plays a very important role in encouraging girls to contemplate their professional future in computing.

III. Methodology

We devised a questionnaire for students in the Introduction to CS course (the first programming course) taken by different majors at the University of Brasília, one of the top 10 Brazilian universities. The questionnaire is composed of 20 questions, divided into personal information, previous programming experience, and intellectual sense of belonging. For this paper, our focus is on the intellectual sense of belonging as described by Stout and Blaney [1]: the perception of being seen as a competent member of the group. We used the same questions as in [1], with a few adaptations to focus only on the sense of belonging among undergraduate students. The five questions were:

- Do you believe that your classmates think that you are not smart enough for your major?
- How many study hours have you spent on the course, outside the classroom, by week?
- Do you think that you need more hours of study than your friends?
- Do you think that your efforts were rewarded (study hours/grade)?
- How often have you felt that you had a great idea that was ignored by your friends?

We applied the questionnaire at the end of the first academic semester of 2020 for the undergraduate students enrolled in the first programming language courses. The University of Brasília offers two such courses: (1) the *Algorithm and Computer Programming* course (ACP) targets undergraduate students in the Computer Science, Computer Engineering, Mecatronic Engineering and Teaching Computer majors, and (2) the *Introduction to Computer Science* (ICS) course offered to students who are not from the Department of Computer Science. We received 178 responses. Table I presents the number of responses by majors: Computer Science, Statistics,

Mechanical Engineering, Mathematics, Building Engineering, Environment Engineering, Production Engineering and Others.

TABLE I
NUMBER OF RESPONSES BY MAJORS.

Major	No. Responses
Computing majors	
Computer Science	15
Computer Engineering	8
Mecatronic Engineering	25
Teaching Computing	15
Non-Computing majors	
Statistics	21
Mechanical Engineering	11
Mathematics	31
Building Engineering	19
Environment Engineering	20
Production Engineering	13

We presented the results about undergraduate students' demographics, followed by the responses for the two groups: Computing majors, which are majors from Department of Computer Science and Non-Computing majors. The results are analyzed in the following sections.

IV. DEMOGRAPHIC OF THE STUDENTS

Table II presents the demographic of the 178 students who answered the questionnaire by gender, age and first-generation students to graduate at higher educational level.

The distribution of the students by gender is: female students 38.2% (68), male students 61.8% (110). For the Computing majors, female students make up 28.6% (18) and male students 71.4% (45). Two majors had more female than male respondents, the Environment Engineering major with 13 female students and seven male students; and the Mathematics with 16 female students and 15 male students. The other majors had more male than female respondents, which is expected in Science, Technology, Engineering and Math (STEM) majors.

The first programming language courses are taken at the beginning of the major, when the students enroll at the university, therefore the distribution of the students' ages was as expected. Only one student in the CS major declared less than eighteen years old. Most of the students are 18-20 years old 62.9% (112), 25.8% (46) are between 20-23 years old, 9.6% (17) are more than 23 years old.

The distribution of the students who declared to be the first generation in their family, i.e., with parents who did not graduate from higher education: 35.9% (64) are first generation (Yes) and 64.1% (114) are not.

V. RESPONSES OF THE QUESTIONNAIRE

This section presents the answers to the questionnaire in Section III. To verify if there is a relationship between gender and answers given in different questions, we used the chi-square test of independence [37]. When the chi-square approximation was questioned due to the small number of answers for some questions, it was used Fisher exact test [38] instead.

TABLE II
DEMOGRAPHIC OF THE STUDENTS.

Gender		
Female	68	38.2%
Male	110	61.8%
Age		
$\leq$ 17 years	3	9.6%
18 - 20 years	112	62.9%
20 - 23 years	46	25.8%
>23 years	17	9.6%
First Generation		
Yes	114	64.1%
No	64	35.9%

1) Do you believe that your classmates think that you are not smart enough for your major?: Figure 1 presents the responses from the CS majors undergraduate students and the students in the non-Computing majors. As we can see most female students in both Computing and non-Computing majors answered "No (N)" to this question. The similar results we found for male students. For Computing majors the percentage of female students who answered "Yes (Y)" is a little higher than for non-Computing female students. For Computing majors, the Fisher exact test was used and there is no evidence of a relation between gender and response to this question (p-value almost 1). For non-Computing majors, the chi-square test of independence does not indicate evidence against independence between gender and response to this question (p-value = 0.1605).

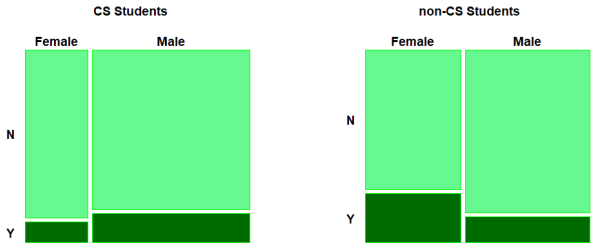

Fig. 1. Responses for the question: Do you believe that your classmates think that you are not smart enough for your major?

2) How many study hours have you spent on the course outside the classroom by week?: Figure 2 presents the result for Computing majors. We can see an almost random distribution of responses from female and male students with the smallest proportion studying 10 or more hours per week. Similarly to Computing students, for non-Computing majors, we found a random distribution of responses. Here we used Cochran-Mantel-Haenszel (CMH) test for homogeneity of responses of both genders over an ordinal variable number of hours. For CS students, the test was not significant (p-value = 0.81876) indicating no evidence of different distribution of the number of hours of study for gender. For non-CS students, the test was also not significant (p-value = 0.345092).

3) Do you think that you need more hours of study than your friends?: Figure 4 shows that the majority of female

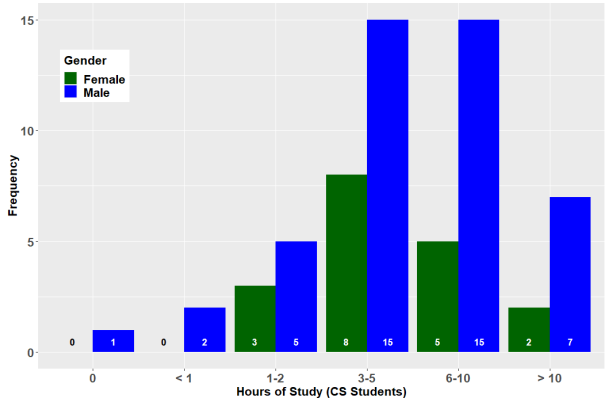

Fig. 2. Responses of CS students for the question: How many study hours have you spent on the course outside the classroom by week?

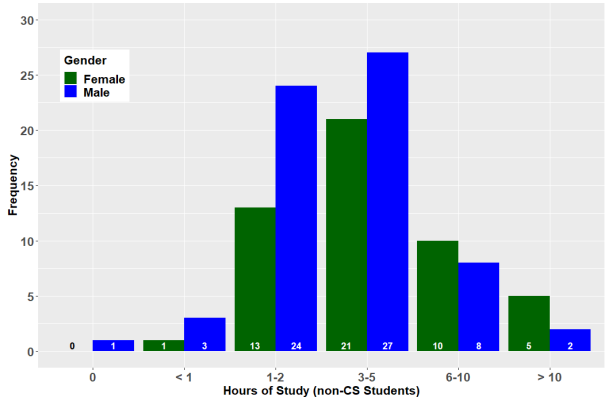

Fig. 3. Responses of non-CS students for the question: How many study hours have you spent on the course outside the classroom by week?

students in CS majors, answered ”Yes (Y)” to this question. On the other hand, most of the male students answered ”No (N)” to this question. Here the chi-square test was significant (p-value = 0.0002108) showing that males tend to think they do not need more hours of study while females do. For non-CS majors, most of the female students answered ”Yes (Y)” however, for the male students the ”Yes (Y)” and ”No (N)” responses were almost equal. The test was not significant at level 0.05 (p-value = 0.0955) but we can observe that if we were less conservative and used a significance level of 0.10, the null hypothesis of no relation would be rejected. For this reason, we considered this test as inconclusive.

4) Do you think that your efforts were rewarded (study hours/grade)?: The results are presented in Figure 5 for CS majors and show a significant difference in perception of Effort-Reward, most of the female students answered ”Yes (Y)” and most of male students answered ”No (N)”. Chi-square test was significant at level 0.05 (p-value = 0.02287). For non-Computing majors, we did not find any significant difference in perception of Effort-Reward, both groups of students, male and female, answered ”Yes (Y)” to this question. Chi-square test was not significant (p-value = 0.3705).

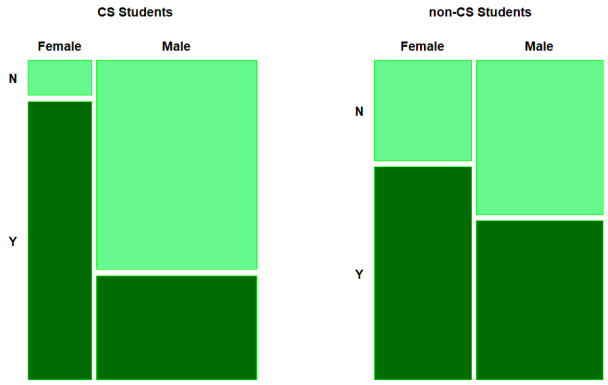

Fig. 4. Responses for question Do you think that you need more hours of study than your friends?

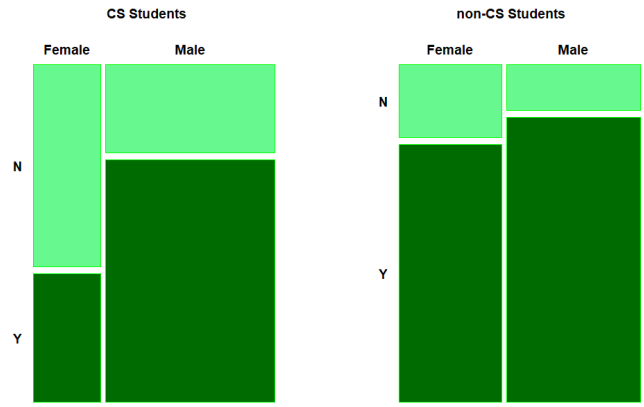

Fig. 5. Response for the question: Do you think that your efforts were rewarded (studyhours/grade)?.

5) How many times have you felt that you had a great idea but your friends ignored it?: Figure 6 presents the responses of CS major students, the responses from both male and female students are distributed over the whole range of frequency, but the vast majority of male students answered ”Never”. For female students, there was a similar number of answers for ”Never” and ”sometimes”. The CMH test was significant (p-value = 0.00387795). There is a different distribution between gender, with proportionally more females feeling that their ideas were sometimes ignored than males. Figure 7 shows that both female and male non-Computing major students answered this question in a similar way.

VI. Analysis

In this section, we discuss the two main research questions based on the answers in the previous section.

A. How does the intellectual sense of belonging of the female students compare to the male students in the Introduction to Computer Science courses in CS majors?

We could not identify a significant difference for all the questions about the first programming course in our university for both, male or female students, which they felt the same for the question, ”Do you believe that your classmates think

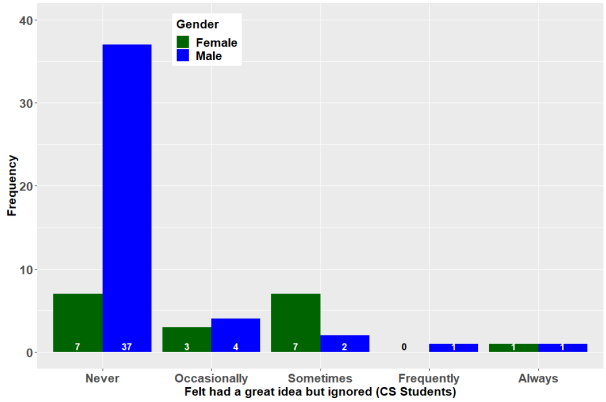

Fig. 6. Response of CS students for the question: How many times have you felt that you had a great idea but your friends ignored it?

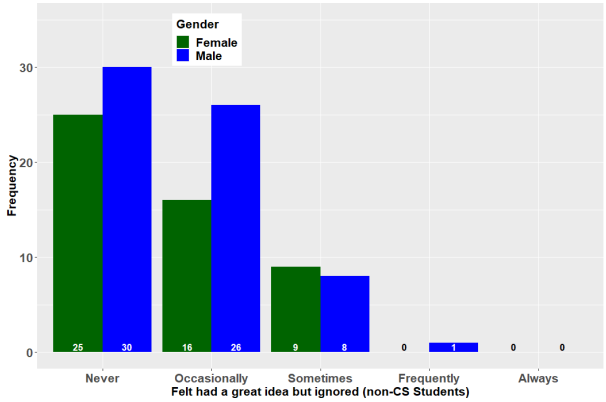

Fig. 7. Response of non-CS students for the question: How many times have you felt that you had a great idea but your friends ignored it?.

that you are not smart enough for your major?", only 11% of female students answered, "Yes", compared to 16% of male students. Neither female nor male undergraduate students believe that their friends think they are not smart enough to do their CS majors. However, we found differences between female and male undergraduate students for the other questions. Initial findings indicate that the female students feel worse than the male ones when we analyze their answers:

- for the question, "Do you think that you need more hours of study than your friends?", female students from the Computing majors answered "Yes" (88.9%), more than the male students (33.3%).
- for the question "Do you think that your efforts were rewarded (study hours/grade)?", female students from Computing majors answered "Yes" (38.9%), less often than male students (66%).
- for the question "How many times have you felt that you have had a great idea but your friends ignored it?", the female students answered "Never" (38.9%), less frequently than male students answered "Never" (73.3%).

B. Is it similar for female undergraduate students in both CS and non-CS majors?

We found that CS female students felt worse than non-CS female students in all questions:

- for the question, "Do you think that you need more hours of study than your friends?", female students from the Computing majors answered "Yes" (89.9%) more than female students from non-Computing majors (68%).
- for the question "Do you think that your efforts were rewarded (study hours/grade)?", female students from Computing majors answered "Yes" (38.8%), less often than female students from non-Computing majors (81.3%).
- for the question "How many times have you felt that you have had a great idea but your friends ignored it?", female students from Computing majors answered "Never" (38.8%), less often than the female students from non-Computing majors (55.5%).

VII. Limitations

The small number of students that answered the questionnaire could limit generalizations of our conclusions. Data for this study were collected at a single time point. As such, findings from this study cannot be used to infer causation between introductory computing experiences and the outcome variables. Nevertheless, data from this study do suggest that first-generation women with high exposure to select introductory course experiences fare better than first-generation women with low exposure to those experiences.

In future studies, we intend to apply probability sampling designs to allow generalization of our studies and also create better mechanisms to motivate instructors and students to answer the questionnaire.

VIII. Conclusion

In this paper, we investigate the sense of belonging in female and male students in CS and non-CS majors. We applied the questionnaire in the first programming course, which is the fundamental point in the first year of the undergraduate students. The initial insights provided by this analysis show that female students in CS majors feel worse than their male counterparts. Furthermore, female students in CS majors also feel worse than female students in non-CS majors. Awareness of the role that sense of belonging may have on retention helps the department create activities that improve the academic environment and may result in better retention outcomes. After this survey, the department created a program to onboard undergraduate students.

As future work, we intend to apply the questionnaire for advanced courses in the CS major curriculum to identify other variables that could be influencing the intellectual sense of belonging. We are developing a web tool to present to instructors, in the first week of the course, the demographic of their class sections. The tool has information about first-generation students, students' previous experience in programming, and gender. This information can be valuable for instructors to

adapt the course activities to better suit the student groups in the classroom.

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