What do Female Students in Middle and High Schools Think about Computer Science Majors in Brasilia, Brazil? A Survey in 2011 and 2019

1st Maristela Holanda
Department of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-0883-2579

2nd Roberto N. Mourao
Department of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-4087-0102

3rd George von Borries
Department of Statistics
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-9072-2247

4th Guilherme N. Ramos
Department of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0001-5859-7362

5th Aleteia Araujo
Department of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0003-4645-6700

6th Maria Emilia Walter
Department of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0001-6822-931X

Abstract—Research Full Paper - Computer Science majors lack gender diversity in Brasília, Brazil. Women are an under-represented minority group in these majors. At the University of Brasilia, one of the top ten universities in Brazil, female under-graduate students account for less than 15% of the students in the Department of Computer Science. In an effort to understand the lack of interest in Computer Science majors among women, this paper addresses the following research questions: 1)Are female students in high school aware that Computer Science majors are predominantly male? 2)Are families of girls from Brasília supportive of their enrolment in Computer Science majors? 3)Do girls from Brasília think that Computer Science majors need a lot of Math? 4)Do female students in high school think that it is difficult to get a job in the field of Computing, with a good salary, and sufficient leisure time? and 5)Which factors influence a female student's choice of a Computer Science major? We devised a questionnaire and applied it to female students in middle and high school on two occasions, in October 2011 (1391 responses) and in July 2019 (429 responses). This paper presents the analysis of the data from the responses, which indicates that the girls' perceptions of Computing have not changed in those years.

Index Terms—Women, Computer Science, female student, undergraduate, high school

I. INTRODUCTION

Female students in Computer Science (CS) majors are an underrepresented group in Brazil and other countries. Women account for an average of only 17% of all graduates in various majors related to Computing in Brazil in the years between 2000 and 2013 [1]. In the same period, male participation in CS majors increased by nearly double while female partici-pation decreased by almost 10%. In addition, in 2017 only 15.44% of the graduates in majors related to Computing in Brazil were women, according to the Brazilian Society on Computing (SBC) [2].

Many educational initiatives have focused on how to im-prove this scenario and have proposed strategies to encourage girls to pursue a profession in Computer Sciences [1], [3], [4]. This issue is internationally debated in groups such as IEEE Women in Engineering, ACM's Women *ACM-W*, *Grace Hopper Celebration of Women in Computer Sciences* [5], *Girls Who Code* [6], among others. All have the common goal of supporting and increasing the number of women in Computing.

SBC fosters the *Meninas Digitais* program, which originated from the *Women in Information and Technology* workshops with the objective of presenting initiatives to include more women in Computer Science in Brazil. In 2013 and 2018 Brazilian Government agencies, such as the Ministry of Sci-ence and Technology, called for research projects specifically related to the education of girls in STEM (science, technology, engineering and mathematics) majors.

One of the main challenges in the efforts to reduce the gender gap in Brazil is understanding why girls do not want a career in Computer Science. Studies show that from the 1980s on, their interest in STEM careers decreased [7], and there is a perception of computer science as a more masculine field in general [8] - a scenario that persists in current times [9].

In an attempt to understand how middle and high school girls perceive CS majors, we devised a questionnaire and applied it on two occasions, 2011 and 2019. Pursuing insights into Brazilian women's lack of interest in these majors, this paper addresses the following research questions: 1)Are female students in high school aware that Computer Science majors are predominantly male? 2)Are families of girls from Brasília supportive of their enrolment in Computer Science majors? 3)Do girls from Brasília think that Computer Science majors need a lot of Math? 4)Do female students in high school think

that it is difficult to get a job in the field of Computing, with a good salary, and sufficient leisure time? and 5)Which factors influence a female student's choice of a Computer Science major? . We analyzed almost 2000 responses, and this paper presents the results.

The rest of this work is organized as follows: Section II presents the background to women and computing; Section III provides details of the methodology; Section IV presents the findings; Section V discusses the results; and concluding remarks are given in Section VI.

II. WOMEN IN COMPUTING

The lack of the gender diversity in Computing has long been reported [10], and recent articles confirm that the issue persists nowadays [11], [12]. Though many studies and interventions have been presented about Women in Computing, it is an issue of more than academic importance. Decreasing the gender gap in Computing, besides encouraging diversity, is fundamental for the development of innovation and inclusive work forces for computing companies [13]–[15]. Several initiatives have been taken to this end.

Stout et al. [16] and Cheryan et al. [17] provide studies about stereotyping in Computer majors, also highlighting that there is a higher ratio of men than women in this field in the US. Likewise, Mercier et al. [8] present surveys, drawings, and interviews in order to examine the perception of US middle school students about characteristics of knowledgeable computer users. These results showed the cultural stereotypes of a computer user: 89% were male and 94% wore glasses. Berg et. al. [18] describe their investigation into the perceived stereotypes in Computing at high school in Scotland, the results identified stereotype misconceptions regarding physical appearance and personality type concerning female students.

Keinan et al. [19] show data that the ratio of graduated women from CS Bachelor programs in the US was almost 40% in 1984, dwindling to 20% by 2006. Vardi [20] has similar results, and adds that in 2013 and 2014, only 14.7% of the graduates were women. The National Center for Women & Information Technology [21] reports that under 20% of the US CS bachelor graduates in 2017 were female.

Kordaki and Berdousis [22] present a study in Greece, considering all higher educational levels (undergraduate, master and PhD students) in Computing and Engineering during the decade 2002-2012, showing that females were less prevalent than male. Papastergiou [23] used descriptive statistics, principal component analysis and analysis of variance to investigate 358 Greek high school students' intentions and motivation for pursuing academic CS studies. 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. The analysis showed that a lack of exposure to and use of computers at home and in school from early stages in their lives seem to be the main factor discouraging them from CS studies, even more when considering the data for girls.

Anderson et al. [24], in Australia, applied Mann-Whitney U test comparison, means, and non-parametric statistics to study possible factors related to low rates of female participation in education pathways leading to information and communication technology (ICT) professions, considering data from a three-year period. The survey had binary options, such as "I am very interested in computers", and "I am not interested in computers", which were presented to 1,453 high school girls in their Senior year. The study identified two factors associated to a woman's aversion to ICT careers: the perception that the subject is boring and an intense dislike of computers.

Maia [1] describes a similar situation in the study on female participation in CS majors in Brazil, based on the Higher Education Census data from the Ministry of Culture and Education between the years of 2000 and 2013. One of the issues raised was that, while the number of male graduates increased 98% in that period, the number of female graduates decreased 8%. In 2017, 15.44% of the Brazilian graduates in CS-related majors were women [2].

Weidler-Lewis et al. [25] present a large study considering high schoolers' perception of CS-related majors, and the factors that influence girls to enroll and continue in them - one of the main factors being social support. Outlay and Platt [26] highlight the importance of the summer camp and of including computing lessons for young women. Gannod et al. [27] also present the important role that attending summer camp had in encouraging female students to attend CS-related majors. Friend [28] reports that experience using computers is necessary but not sufficient and social support is an important factor for girls to envision a future career in computing.

III. METHODOLOGY

The enrollment of female students in Computer Science majors is decreasing every year in Brazil and one of the biggest challenges in addressing this is to discover why girls avoid them. Our research intends to further investigate the perceptions of the Computer Science field by looking at the perception of the girls in middle and high school. To this end, we have analysed the data obtained from surveys in 2011 and 2019.

We devised a questionnaire to enquire about female middle and high school students' perceptions of the Computer Science field. It included questions about the profile, such as gender, school year, field of interest for higher education, and about the perception of the field of Computing as follows:

1) Is the majority of Computer Science majors' students male?
2) Would your family like you to take the college entrance exam for Computer Science?
3) Does a university computer science course require only a few math skills?
4) Is it difficult to find work in Computer Science after graduating?
5) Do people who work in Computer Science have little leisure time?
6) Does working in Computer Science pay well?

A. Application of the questionnaire

The application of the questionnaires happened in two different periods, 2011 at a conference, and 2019 in the schools.

In 2011, they were given to female students in high school in our City, during the National Science Conference of the Brazilian Ministry of Science and Technology, and 1391 responses were collected. This conference had many stands for majors, such as Biology, Math, Computer Science, and other departments. When female students came to the Computer Science stand, we asked them to respond to the questionnaire, in person, and voluntarily.

At the beginning of the academic year of 2019, we sent the questionnaire to eight schools in the different regions of our federal unit. The teachers in the classroom asked girls to respond to the questionnaire, providing us with 429 responses.

The Brazilian Center for Research in Evaluation, Selection, and Promotion of Events (CEBRASPE) handled the printing of the questionnaires and reading of the responses, providing a spreadsheet with all the data.

B. Sampled Population

This study used a sample of convenience and usually, this kind of sample is biased since the units easiest to select are not representative of those which are harder to select. However, the descriptive study allowed us to obtain a first impression of this population.

The city and its surroundings have had a steadily increasing population since the 1960s. According to the Brazilian Institute of Geography and Statistics (IBGE), the region's estimated population was over 2.5 million in 2011, and over 3 million in 2019. Based on the same projections, the number of people aged between 15 and 19 was 225,306 and 239,651; and the ratio of female students with this age interval was 51% and 49%, for 2011 and 2019, respectively.

In 2011, the number of applications for middle and high schools, according to the Secretary of Education, was 84,849 for public and 27,675 for the private schools. In 2019, these numbers were, respectively, 82,041 and 25,784. Therefore, the estimated ratio of girls attending the public middle and high schools was 75% in 2011, and 76% in 2019.

IV. Findings

This section is composed of two subsections: general information, information about the choice of majors; and, the Computing field perception, we present the findings of the questions specifically about Computer Science majors.

A. General Information

Figure 1 shows the respondents' interest in three different scientific fields of majors: Exact Science (ES), Biology-Health Science (BHS), and Human Sciences (HS). The data indicates that, BHS was the preferred field in both surveys, while HS had around 38% preferences in them. Exact Sciences, the Computer Science's field, is the least interesting for both 2011 and 2019 groups.
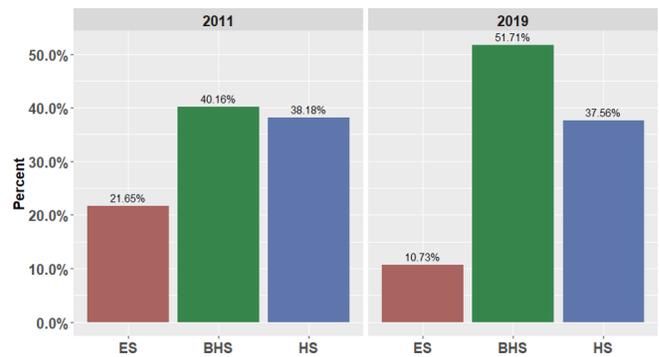

Fig. 1: Respondents' interest in scientific fields in 2011 and 2019.

Figure 2 shows the respondents' interest in enrolling in a CS major. The response "No" has the lowest number of the respondents in both surveys, around 25% in both groups. The "Don't Know" option jumped from 34.7% in 2011 to 46.2% in 2019 while the percentage of girls who answered "Yes" dropped from 41.9% to 28.1%.
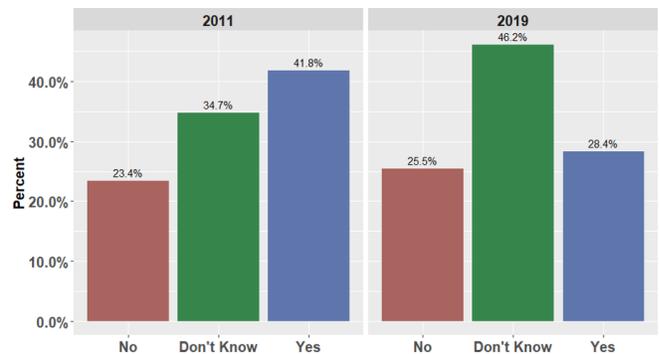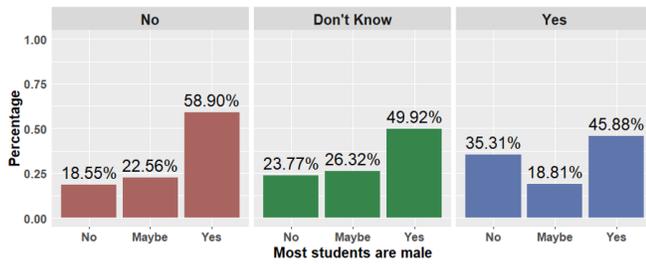

Fig. 2: Respondents interested in Computer Science.

B. Answers to the Research Questions

All figures present the distribution of answers to a specific question considering, for the same respondent, the answer to her intention of enrolling in a CS major. Thus, red histograms show answers for girls who are not interested in a CS major, blue histograms for those who would like a CS education, and green for those who answered they do not know.
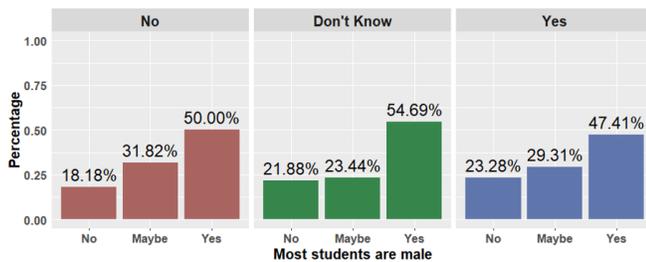
RQ1) Are female students in high school aware that Computer Science majors are predominantly male? Figure 3a presents the distribution of RQ1 answers for the 2011 group. We can see that the majority of the girls think that CS is indeed predominantly a male field, over 45% in all scenarios. Girls who will not or don't know if they would enroll in a CS major (red and green histograms, respectively) have similar answers. It is clear, however, that girls who would not enroll (red histogram) strongly perceive the gender difference in the field: almost 59% responded "Yes" and only 17.55% responded

"No". Those that are interested in CS (blue histogram), have a different perception on this issue, 35.31% responded "No" (almost twice as many as the previously discussed group) and 45.88% responded "Yes" (about 22% less).

Figure 3b presents similar results for the 2019 group, and we can see the result is similar for all groups. All have at least 45% responses perceiving the CS field as predominantly male and around 20% thinking it is not. The positive point was that for girls interested in CS majors, the answer "No" decreased to 23.28%.

(a) 2011

(b) 2019

Fig. 4: Perception of family support per interest in pursuing a CS major.
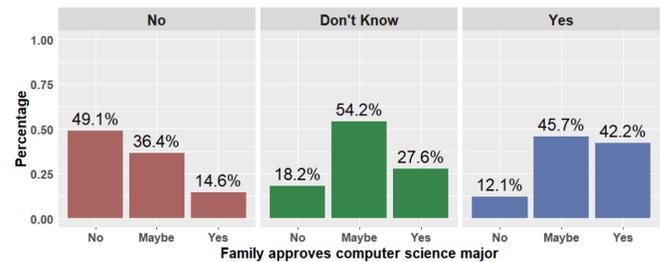

(a) 2011

(b) 2019

Fig. 3: Perception of CS as a predominantly male field per interest in pursuing a CS major.

RQ2) Are families of girls from Brasília supportive of their enrolment in Computer Science majors? Figure 4a and Figure 4b show the result for the question "Would your family like you to take the college entrance exam for Computer Sciences?", which are similar in 2011 and 2019. The girls who expressed interest in enrolling in CS majors had the highest number of "Yes" replies (47.46% in 2011 and in 2019 42.2%). The lowest percentages of "Yes" replies were from those girls who stated they had no interest in CS majors (14.93% in 2011 and 14.6% in 2019).

RQ3) Do girls from Brasília think that Computer Science majors need a lot of Math? Figure 5a and Figure 5b show the result for the question "Does a Computer Science major

require only a few math skills?". Here we can see, in all groups ("Not" interested in a CS major, "Don't Know" or "Yes", interested in a CS major) the answer "No" was given most in both 2011 and 2019. Clearly, the girls know the Computer Science majors involve a lot of Math.

RQ4) Do female students in high school think that it is difficult to get a job in the field of Computing, with a good salary, and sufficient leisure time? Questions 4, 5 and 6 of the questionnaire provided answers to this question.

Figure 6a and Figure 6b show the result for Question 4) "Is it difficult to find work in Computer Science after graduating?". In 2011, in all groups ("Not" interested in a CS major, "Don't Know" or "Yes", interested in a CS major) the answer "No", was given most often, and "Yes" least. In 2019, the answer, "Maybe" was given most often by the groups not interested in CS majors and the undecided. For the girls who were interested in CS majors, the answer "No", was the highest. In 2019, the lowest rate was for the answer "Yes".

Figure 7a and Figure 7b show the result for Question 5) "Do people who work in Computer Science have little leisure time?". In 2011, all groups the answer "No" was given most frequently, and, "Yes", least frequently. In 2019, in all groups responded with "Maybe" most frequently, and, "Yes", least frequently.
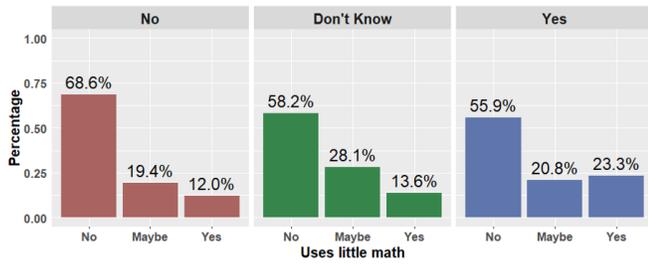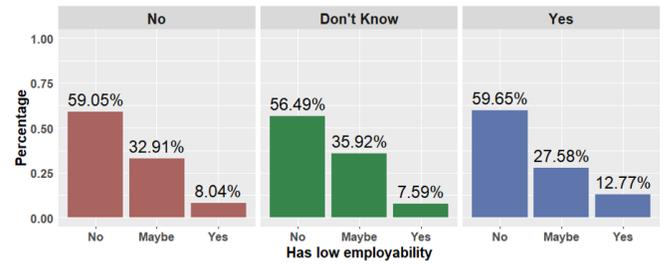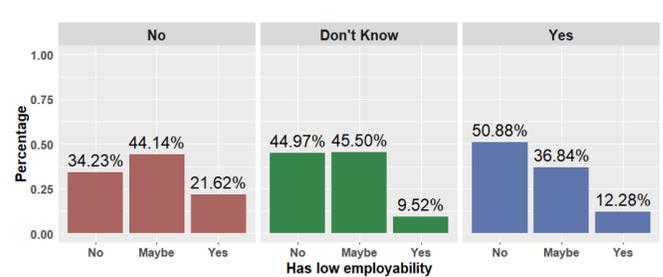
(a) 2011
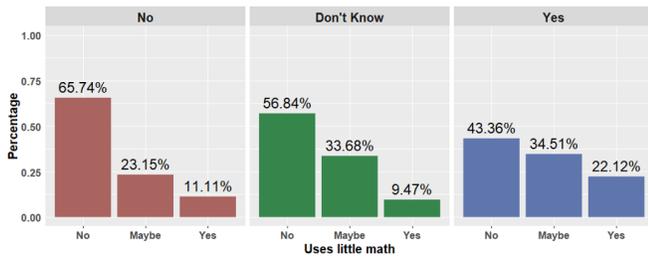
(b) 2019

Fig. 5: Perception of required math skills per interest in pursuing a CS major.

(a) 2011

(b) 2019

Fig. 6: Perception of employment per interest in pursuing a CS major

Figure 8a and Figure 8b present the replies to question 6) "Does working in Computer Sciences pay well?". In 2011 and 2019, for all groups the answer "No" was given least frequently. In both 2011 and 2019, "Maybe" was common among all groups.

**RQ5) Which factors influence a female student's choice of a Computer Science major?**

We applied association rules analysis mining [29] on the data to answer this question, which produces straightforward the rules stating "*if A occurred, then B occurs*". For example, the rule "*if a girl sees the Computing field as boring, she will not enroll in a CS major*" was found. In order to select which rules are more relevant, we consider their level of association between the antecedent and their consequent, called *lift* [30].

Considering the possibility of enrolling in a CS major, Table I presents the rules with highest lifts with the same antecedent and consequent for 2011 and 2019. The antecedent considering family approval has high lift values, indicating that a non negative approach (answers "yes" and "maybe") has a strong influence in their choice of enrollment.

We can see that with the antecedent "use computer in lan house, yes", the female students would enroll in a CS major, yes. And, when the girls answered no, they would not enroll in CS majors. A "lan house" in Brazil is a place that rents computers for a short period of time (by the minute or hour).
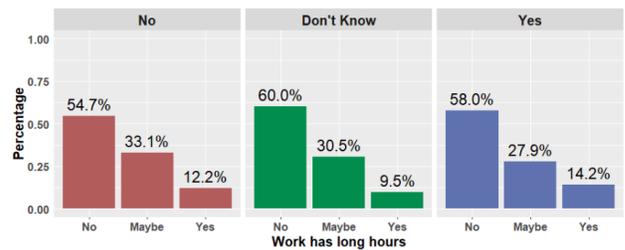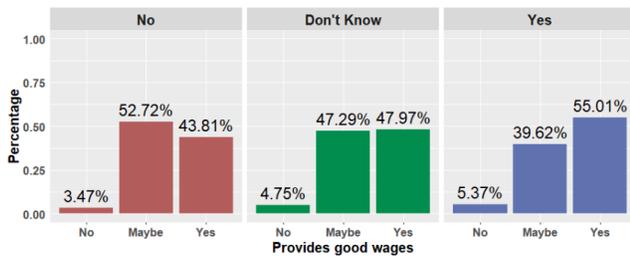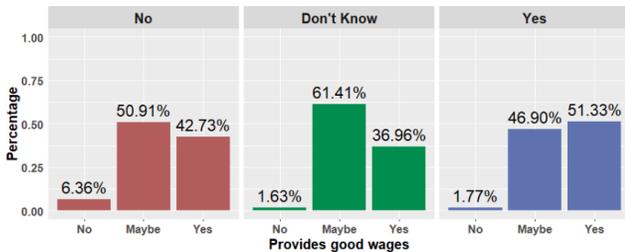

(a) 2011
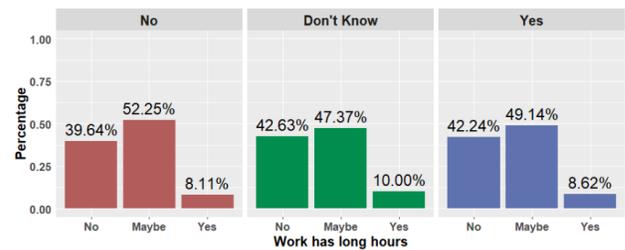
(b) 2019

Fig. 7: Perception of work hours per interest in pursuing a CS major.

Many schools in this survey are in disadvantaged areas, and

(a) 2011

(b) 2019

Fig. 8: Perception of wages per interest in pursuing a CS major.

TABLE I: Lifts of association rules concerning potential enrollment in CS major.

Antecedent	Would enroll in CS?	2011	2019
Family Approves = Yes	*Yes*	*1,46*	*1,49*
Family Approves = Maybe	Maybe	1,33	1,14
Uses Lan House = Yes	Yes	1,15	1,45
Uses Lan House = No	No	1,23	1,14
Higher Education Required To Work In CS = Yes	Yes	1,15	1,21

the female students use the lan house to have access to a computer and the internet when none is available at home.

The final rule of note states that if they are aware that higher education is required to work in the CS field, then they would enroll in such major. This leads to the knowledge that girls who are indeed interested in computing are aware that it requires further studies.

V. DISCUSSION

Despite the efforts of the government and SBC supporting projects to include more women in CS-related majors, in Brazil, this group has been underrepresented in the last decade. Similarly, our survey shows middle and high school female students' perception of Computing didn't change in 2011 and 2019.

Some factors related to literature, such as, family approval, was confirmed for Brazilian girls in high school. In 2011 and 2019 most female students intending to enroll on CS-related majors had family support.

In 2011 and 2019, the majority of female students knew that there are more male than female undergraduate students in CS-related majors. It is possible that the male stereotype in computing is a factor for women not enrolling in CS majors.

Brazil has been going through an economic crisis during the last 10 years, this is a sensitive issue in Brazil's current context, the February 2020 unemployment rate was 11.4% [31]. However, for female students the career opportunities in Computing do not seem to be an important factor. Most female students declared that it is easy to find a job in the Computing field.

Brazilian female students were quite aware of the Math involved in a CS major, in 2011 and 2019. This notion, associated with the country's ongoing difficulties on teaching Math in schools, as reported by the National Institute for Educational Studies and Research [32], might be an important factor discouraging girls.

An interesting observation was the high rate of the answer "Maybe" for questions related to work in the area of Computing. More needs to be done to raise awareness of the opportunities for work in the Computing field.

The use of lan houses seems to influence whether female students would enroll in CS majors. This is important in the context of the respondents, most of whom struggle with socioeconomic issues.

Finally, these findings and the discussions they sparked provide insights into factors that influence girls when choosing, or not, a CS major in Brazil, and these can lead to actions to mitigate the gender disparity.

VI. CONCLUSION

The gender gap in the Computing field has widened and girls have not shown interest in majoring or becoming professionals. In order to address the issue, this paper presents a survey conducted on two occasions, 2011 and 2019, to understand the girls' perception of a CS major.

We found that middle and high school girls in Brazil, know that a CS major is a field with a lot of male students. The math is an important skill required to enroll on a CS majors, and finding a job is not a problem in the Computing field. Finally, family support is an important factor in the girls' choice of a CS major.

After the first findings in 2011, the University of Brasília created initiatives to include more girls in CS-related majors, such as: inviting the parents with their girls to participate in our workshops; providing lectures specifically about jobs in computing and lectures featuring important women in the field; offering activities involving Mathematics, Computing and games.

Future works include: improving the questionnaire, for example, by improving our including questions about perception of Math in High School; applying the analysis to data for High School boys, for comparison, as well as to students who have enrolled in a CS major; and investigating the data mining approaches for knowledge discovery.

REFERENCES

[1] M. M. Maia, "Limites de gênero e presença feminina nos cursos superiores brasileiros do campo da computação," *Cadernos Pagu*, vol. 0, no. 46, pp. 223–244, 2016.

[2] D. J. Nunes, "Educação superior em computação, estatísticas 2017," *SBC*, vol. 1, no. 1, 2017.

[3] J. M. Cohoon, "Recruiting and Retaining Women in Undergraduate Computing Majors," *SIGCSE Bull.*, vol. 34, no. 2, pp. 48–52, jun 2002.

[4] D. Gürer and T. Camp, "An acm-w literature review on women in computing," *SIGCSE Bull.*, vol. 34, no. 2, pp. 121–127, Jun. 2002.

[5] G. C. Townsend and K. Sloan, "Pre- to post-conference differences: Celebrations of women in computing," in *2016 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2016, pp. 1–8. [Online]. Available: http://ieeexplore.ieee.org/document/7757644/

[6] K. M. Miltner, "Girls who coded: Gender in twentieth century u.k. and u.s. computing," *Science, Technology, & Human Values*, vol. 44, no. 1, pp. 161–176, 2019. [Online]. Available: http://journals.sagepub.com/doi/10.1177/0162243918770287

[7] J. Abbate, *Recoding Gender: Women's Changing Participation in Computing*, 1st ed. One Rogers Street Cambridge MA 02142-1209: The MIT Press, 2012.

[8] E. M. Mercier, B. Barron, and K. M. O'Connor, "Images of self and others as computer users: the role of gender and experience," *Journal of Computer Assisted Learning*, vol. 22, no. 5, pp. 335–348, 2006.

[9] F. C. Payton and E. Berki, "Countering the negative image of women in computing," *Commun. ACM*, vol. 62, no. 5, pp. 56–63, Apr. 2019.

[10] K. A. Frenkel, "Women and computing," *Communications of the ACM*, vol. 33, no. 11, pp. 34–46, 1990-11-01. [Online]. Available: http://portal.acm.org/citation.cfm?doid=92755.92756

[11] M. Y. Vardi, "How we lost the women in computing," *Communications of the ACM*, vol. 61, no. 5, pp. 9–9, 2018. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3210350.3201113

[12] F. C. Payton and E. Berki, "Countering the negative image of women in computing," *Communications of the ACM*, vol. 62, no. 5, pp. 56–63, 2019. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3328504.3319422

[13] W. M. DuBow, "Diversity in computing: Why it matters and how organizations can achieve it," *Computer*, vol. 46, no. 3, pp. 24–29, 2013. [Online]. Available: http://ieeexplore.ieee.org/document/6407461/

[14] W. DuBow, "Attracting and retaining women in computing," *Computer*, vol. 47, no. 10, pp. 90–93, 2014. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6926714

[15] W. M. DuBow, B. A. Quinn, G. C. Townsend, R. Robinson, and V. Barr, "Efforts to make computer science more inclusive of women," *ACM Inroads*, vol. 7, no. 4, pp. 74–80, 2016. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3018995.2998500

[16] J. G. Stout, V. A. Grunberg, and T. A. Ito, "Gender roles and stereotypes about science careers help explain women and men's science pursuits," *Sex Roles*, vol. 75, no. 9, pp. 490–499, 2016.

[17] S. Cheryan, V. C. Plaut, C. Handron, and L. Hudson, "The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women," *Sex Roles*, vol. 69, no. 1, pp. 58–71, 2013.

[18] T. Berg, A. Sharpe, and E. Aitkin, "Females in computing: Understanding stereotypes through collaborative picturing," *Computers & Education*, vol. 126, pp. 105–114, 2018. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S0360131518301829

[19] E. Keinan, "A New Frontier: But for Whom? An Analysis of the Micro-Computer and Women?s Declining Participation in Computer Science," Claremont McKenna College, Tech. Rep. 1466, 2017.

[20] M. Y. Vardi, "What can be done about gender diversity in computing?: A lot!" *Commun. ACM*, vol. 58, no. 10, pp. 5–5, Sep. 2015.

[21] N. C. for Women and I. T. (NCWIT). (2019) Ncwit scorecard: The status of women in computing. [Online]. Available: https://www.ncwit.org/

[22] M. Kordaki and I. Berdousis, "Computing and STEM in greece: Gender representation of students and teachers during the decade 2002/2012," *Education and Information Technologies*, vol. 22, no. 1, pp. 101–124, 2017.

[23] M. Papastergiou, "Are Computer Science and Information Technology still masculine fields? High school students' perceptions and career choices," *Computers & Education*, vol. 51, no. 2, pp. 594 – 608, 2008.

[24] N. Anderson, C. Lankshear, C. Timms, and L. Courtney, "'Because it's boring, irrelevant and I don't like computers': Why high school girls avoid professionally-oriented ICT subjects," *Computers & Education*, vol. 50, no. 4, pp. 1304 – 1318, 2008.

[25] J. Weidler-Lewis, W. DuBow, A. Kaminsky, and T. Weston, "Supporting women's persistence in computing and technology," *Information and Learning Sciences*, 2019.

[26] C. N. Outlay, A. J. Platt, and K. Conroy, "Getting IT together: A longitudinal look at linking girls' interest in IT careers to lessons taught in middle school camps," *ACM Transactions on Computing Education*, vol. 17, no. 4, pp. 1–17, 2017. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3134765.3068838

[27] G. C. Gannod, J. E. Burge, V. McIe, M. Doyle, and K. C. Davis, "Increasing awareness of computer science in high school girls," in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*. IEEE, 2014-10, pp. 1–8. [Online]. Available: http://ieeexplore.ieee.org/document/7044456/

[28] M. Friend, "Middle school girls' envisioned future in computing," *Computer Science Education*, vol. 25, no. 2, pp. 152–173, 2015. [Online]. Available: http://www.tandfonline.com/doi/full/10.1080/08993408.2015.1033128

[29] K. Cios, R. Swiniarski, W. Pedrycz, and L. Kurgan, "The Knowledge Discovery Process," in *Data Mining*. Springer US, Jan. 2007, pp. 9–24.

[30] P. Tan, M. Steinbach, and V. Kumar, *Introduction to Data Mining*, ser. Always learning. Pearson Addison Wesley, 2006.

[31] I. B. de Georgrafica e Estatística. (2020) Pesquisa nacional por amostra de domicílios contínua - pnad contínua. [Online]. Available: https://www.ibge.gov.br/

[32] I. N. de Ensino e Pesquisas Educacionais Aníxio Teixeira. (2020) Sistema de avaliação de educação básica. [Online]. Available: http://portal.inep.gov.br/web/guest/educacao-basica/saeb