Intersectional Gender Dynamics in Junior Scientific Research in Computing: Race, Income, and Territorial Dimensions Among Brazilian Girls

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Abstract. *Girls' participation in Computing in Brazil is marked by structural inequalities that are intertwined with race/ethnicity, income, territory, and access to technology. This paper presents a quantitative analysis of the intersectional profile of girls participating in the Junior Scientific Initiation (ICj) of the RENACEE MD project, which brings together ten higher education institutions and 10ten elementary schools in five Brazilian regions. Based on a nationwide project survey and descriptive and inferential analyses, associations were identified among infrastructure, previous experiences, expectations, and gender intersectionalities. The results reveal barriers affecting specific groups and offer practical recommendations for inclusion initiatives, including digital literacy, progressive tracks, contextualized activities, and mentoring.*

Resumo. *A participação de meninas na Computação no Brasil é marcada por desigualdades estruturais que se entrelaçam em dimensões de raça/etnia, renda, território e acesso à tecnologia. Este artigo apresenta uma análise quantitativa do perfil interseccional de alunas de Iniciação Científica Júnior (ICj) do projeto RENACEE MD, que reúne dez instituições de ensino superior e dez escolas de educação básica nas cinco regiões brasileiras. A partir de um survey nacional e de análises descritivas e inferenciais, identificaram-se associações entre a infraestrutura, as experiências prévias, as expectativas e as interseccionalidades de gênero. Os resultados revelam barreiras que afetam grupos específicos e apontam recomendações práticas para iniciativas de inclusão, tais como letramento digital, trilhas progressivas, atividades contextualizadas e mentoria.*

1. Introduction

Despite recent growth in the enrollment of women in Computing programs in Brazilian higher education, women students accounted for only 19% of those enrolled in these degrees in 2024 [INEP 2024]. Structural inequalities related to gender, race, disability, and socioeconomic status persist across these programs, as evidenced by analyses conducted in different regional contexts, such as in Bahia [Pereira et al. 2024] and Santa Catarina [Santos et al. 2023].

Intersectionality [Crenshaw 1989] offers a powerful lens for understanding these overlaps in inequality, recognizing that the interactions of multiple social factors shape the experiences of girls and women. Initiatives to increase the participation of girls and women in Computing must incorporate an intersectional perspective; otherwise, they risk reproducing rather than reducing existing structural inequalities. Understanding the intersectional dynamics that shape access to and persistence in Computing must extend beyond higher education and encompass earlier educational stages. In this regard, the national call "CNPq/MCTI/MMulheres nº 31/2023 – Meninas nas Ciências Exatas, Engenharias e Computação" expanded Junior Scientific Initiation (ICj) scholarships to promote gender and racial equity in STEM areas [CNPq 2023]. The call selected 120 projects across all regions of the country, offering between 2,300 and 4,000 ICj scholarships for basic education students[1].

This paper presents an exploratory quantitative analysis on the profiles of girls participating as ICj students in the "Rede Nacional de Educação e Extensão Meninas Digitais" (RENACEE MD) project, a nationwide initiative supported by the call mentioned above. The project brings together teachers and students from ten higher education institutions and ten basic education schools, distributed across all five Brazilian geographic regions.

To better understand girls' profiles and trajectories, we conducted a survey of ICj students to examine intersectional markers of race/ethnicity, socioeconomic class, and territory. The survey also investigated students' prior exposure to Computing, their access to technological infrastructure, and their expectations regarding the project. Through descriptive and inferential statistical analyses (chi-square tests), the study revealed key insights for planning more inclusive educational interventions to expand girls' participation and retention in Computing.

Beyond this introductory section, the paper is organized into five additional sections. Section 2 presents an overview of diversity and intersectionality in Computing education. Section 3 describes the methodology adopted in this study. Section 4 reports the main findings, followed by a discussion in Section 5. Finally, Section 6 outlines the conclusions and directions for future work.

2. Diversity and Intersectionality in Computing Education

Analyses of gender diversity in Computing Education in Brazil have increasingly adopted critical and intersectional perspectives; however, substantial methodological gaps remain, with few empirical studies available. Lima et al. (2025) identified that less than 3% of Brazilian scientific publications (WEI, EduComp, SBIE) addressing diversity in Computing Education include minoritized groups, and that quantitative intersectional studies are virtually nonexistent. Other research has examined structural inequalities in face-to-face Computing programs using INEP microdata [Pereira et al. 2024, Santos et al. 2023], revealing significant disparities related to gender and race. Although relevant, these studies

[1] Basic education refers to elementary school and high school.

focus exclusively on higher education and do not capture earlier formative dynamics, such as those experienced by girls in basic education.

Amaral and Oliveira (2024) investigated how intersectionality and other values associated with the fourth wave of feminism, such as activism and situated knowledges, emerge in Brazilian Computing publications. Although the term is widely cited, methodological applications remain rare, and existing studies lack integration across gender, race/ethnicity, socioeconomic class, and territory. Complementing this, the systematic mapping by Rodrigues et al. (2025) on intersectionality and technology shows that inequalities in the technology sector are shaped by structural and cultural barriers that disproportionately affect Black and low-income women, and identifies resistance and empowerment initiatives such as {Reprograma} and PretaLab. Nonetheless, the authors highlight the scarcity of quantitative studies and the lack of large-scale empirical analyses.

Quintela et al. (2024) conducted a systematic mapping of tools and strategies to promote gender and racial inclusion in Computing, categorizing pedagogical, technological, and institutional actions. The authors emphasize the need for quantitative metrics and comparable indicators to evaluate the impact of existing initiatives, especially in early educational stages. Moro (2022) argues that Computing programs have not adequately prepared students and educators to address issues of diversity, equity, and inclusion, underscoring the urgency of more engaged and socially responsible pedagogical practices.

In summary, the national literature shows important progress but still treats intersectional markers in a fragmented manner: gender and race [Quintela et al. 2024], and more recently, gender, race, and class [Rodrigues et al. 2025]. However, as pointed out by Lima et al. (2025) , there is a lack of large-scale quantitative studies that jointly integrate gender, race/ethnicity, socioeconomic status, and territory in the Brazilian context.

The present study addresses this gap by conducting descriptive and inferential statistical analyses of the intersectional profiles of Junior Scientific Initiation (ICj) students across Brazil's five regions, offering empirical evidence of structural inequalities that emerge even before entry into higher education.

3. Methodology

This research aims to identify patterns and inequalities related to gender, race/ethnicity, socioeconomic class, and territorial markers. By examining how these factors intersect in the educational pathways of ICj students participating in the *RENACEE MD* project, the study aims to provide a deeper understanding of their combined impact. The methodology follows two main stages: first, a characterization of student profiles through a sociodemographic and technological survey; second, a descriptive and inferential quantitative analysis using an intersectional approach.

The survey was designed following the guidelines proposed by Creswell and Creswell (2018) and was inspired by consolidated instruments used to monitor access to and use of information and communication technologies in the Brazilian context [CETIC.br 2024a]. The study complies with the ethical principles established by Resolution No. 466/2012. All participants provided informed assent to take part in the research, and their legal guardians authorized their participation. The data were anonymized, stored in a secure repository, and used exclusively for scientific purposes.

In the first stage, a questionnaire was developed using *Google Forms* and distributed to the 50 ICj students at the start of the project's first year. The survey was structured to capture sociodemographic and technological profiles, focusing on four key areas: (i) gendered intersectionalities within sociodemographics, (ii) access to technological infrastructure, (iii) previous experience with Computing and digital technologies, and (iv) students' expectations and motivations regarding the project and the Computing field. The supplementary materials (questionnaire and data collected) are available at: `https://bit.ly/3XWT7TL`.

For the quantitative analysis, an exploratory and descriptive approach was used with *Google Colab* and Python libraries (*pandas*, *numpy*, *matplotlib*, *scipy*). This phase included procedures such as:

- **Data cleaning and preparation:** correcting inconsistencies, standardizing categories, and mapping nominal scales to numerical values;
- **Descriptive statistics:** producing frequency tables and bar charts to characterize participants' sociodemographic and technological profiles;
- **Inferential analysis:** investigating associations between intersectional variables (race/ethnicity, region, socioeconomic status, and school grade) and dimensions related to technological infrastructure, technology use, and expectations about Computing. The Chi-square test of independence (χ^2) was employed, as it is suitable for categorical variables [Bilder and Tebbs 2008, Field 2018], along with Cramér's V coefficient to estimate the strength of associations [Cohen 2013]. Relationships with $p < 0.05$ were considered statistically significant and examined descriptively using contingency tables that highlighted intersectional patterns and inequalities.

4. Results

This section presents the study's main findings through an intersectional lens. The analysis begins with the characterization of the intersectional profile of the 45 students who answered the survey, followed by an examination of their technological infrastructure and access conditions, their prior experiences with Computing, and their expectations and professional aspirations related to the project and the technological field. Each analytical block combines descriptive and inferential data, enabling an understanding of how social and contextual factors influence girls' engagement and educational opportunities in Computing.

4.1. Intersectional Profile of the Students

Figure 1 provides an overview of the students' intersectional characteristics, integrating territorial, racial, and socioeconomic dimensions. The map highlights the national scope of the project, with participants distributed across eight states — Amazonas, Pará, Ceará, Paraíba, Goiás, Minas Gerais, Rio de Janeiro, Santa Catarina, and the Federal District, evidencing the regional diversity and the presence of the network in varied educational and socioterritorial contexts across Brazil.

The distribution of students by race/ethnicity and school grade shows a predominance of Parda and White girls, followed by Black girls. Although the racial composition is relatively balanced, the data suggest that Black and Parda students tend to be more concentrated in the final years of middle school and the early years of high school. Regarding

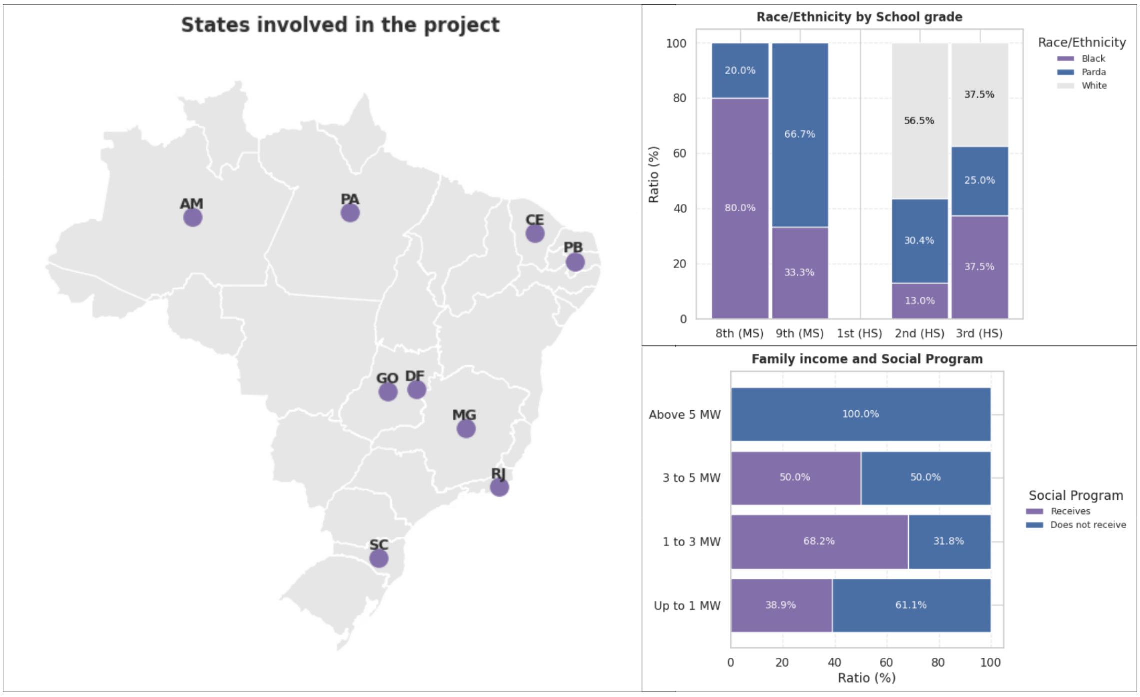

Figure 1. Territorial, racial, and socioeconomic distribution of ICj students.

school grade, most students are in the 2nd year of high school (23), followed by the 3rd year (8) and the final years of middle school (14). This indicates that participants are predominantly in a key stage for career decision-making, reinforcing the project's role in expanding academic and professional horizons.

Concerning family income and the receipt of social benefits, most households fall within the range of up to three minimum wages, with a notable prevalence of students whose families receive social assistance programs such as Bolsa Família and Pé-de-Meia[2]. This intersection of low income and dependence on public social programs highlights the socioeconomic vulnerability experienced by the group, particularly among Black and Parda students.

Taken together, the data presented in Figure 1 illustrate how territory, race, and class intertwine to shape the conditions of access, persistence, and engagement for girls in the Computing field. These findings reinforce the importance of adopting an intersectional approach [Crenshaw 1989] as an analytical lens for understanding the inequalities that affect girls in junior scientific initiation programs in Brazil.

4.2. Technological Infrastructure

Unequal access to technological infrastructure is one of the most evident barriers to students' participation in the project. Figure 2 shows that although smartphone use is nearly universal, access to devices better suited for study and programming activities, such as desktop computers and laptops, is still limited, with only about one-third of students having such equipment.

[2] *Bolsa Família* is a conditional cash-transfer program internationally recognized for its impact on reducing hunger in Brazil. *Pé-de-Meia* is a financial incentive designed to support retention and completion in public high schools

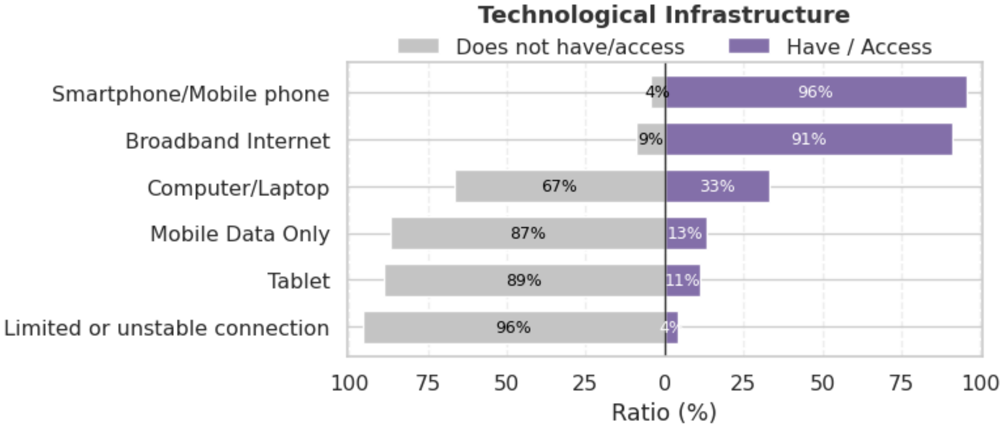

Figure 2. Technological infrastructure of ICj students.

Connectivity also reveals significant disparities: while most students have access to broadband internet, a considerable proportion relies exclusively on mobile networks or faces unstable connections. These technical limitations directly affect participation in synchronous activities and the ability to follow online content, reinforcing inequalities in access to more advanced educational experiences. Taken together, these factors illustrate how material barriers intersect with broader social inequalities, restricting girls' opportunities to engage with Computing and digital technologies more generally.

Associations among profile variables and technological infrastructure indicators (Figure 3) show that students' digital access conditions are deeply tied to regional, age-related, and socioeconomic factors. The results reveal strong, statistically significant correlations among computer or laptop use and the variables State, Region, and Family Income, with Cramér's V values ranging from 0.51 to 0.62 ($p < 0.05$). These findings indicate that access to higher-performance devices strongly depends on territorial context and economic conditions, reinforcing structural inequalities among participants.

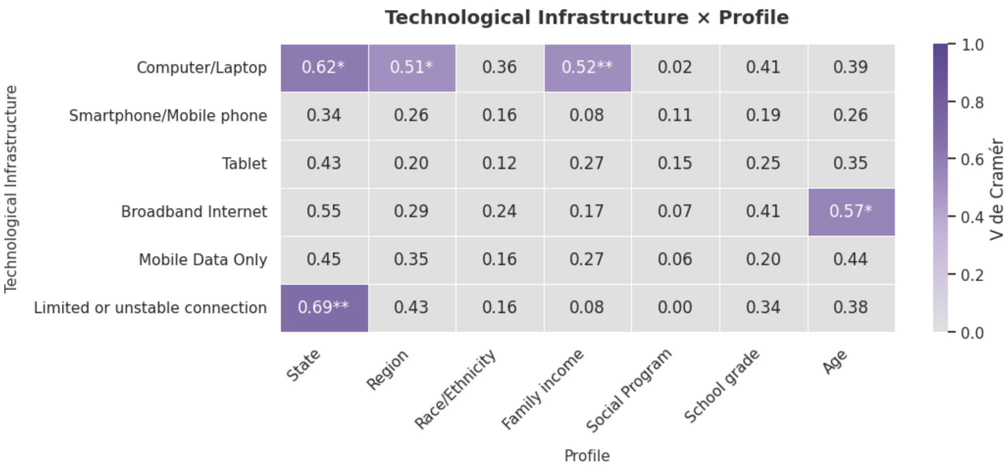

Figure 3. Associations between *Profile* and *Technological Infrastructure*.

Similarly, internet connection stability is significantly associated with both State (V = 0.69; $p < 0.01$) and Age (V = 0.57; $p < 0.05$). This suggests that geographic location and age influence connectivity quality: younger students and those residing in the South and Southeast regions report more stable connections, whereas participants in the North and Northeast face greater instability and rely more heavily on mobile networks.

Overall, the results demonstrate that territorial and economic dimensions play a decisive role in shaping students' technological conditions. Family income and place of residence emerge as key factors of digital exclusion, limiting students' potential for meaningful engagement in educational activities and full access to the project's resources.

4.3. Experiences and Prior Exposure to Computing

The data indicate that, before participating in the project, students had limited exposure to Computing. Figure 4 summarizes the frequency of students' engagement in Computing-related activities and courses; most experiences were irregular. Even among those reporting prior exposure, answers such as 'rarely' or 'sometimes' were common, and only a minority engaged with Computing weekly. These findings confirm the absence of Computing as a structured curricular component and underscore ongoing inequalities in access to technological education during basic schooling.

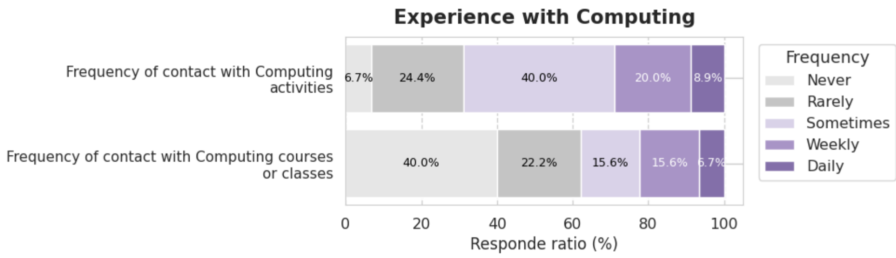

Figure 4. Frequency of prior exposure to Computing.

Figure 5 indicates that students join the project with varying degrees of knowledge and interest in Computing. While most report only basic or moderate knowledge, most indicate a positive interest, with nearly half showing moderate enthusiasm for the field. Therefore, despite educational gaps, students are generally willing to learn, explore, and engage with technological content.

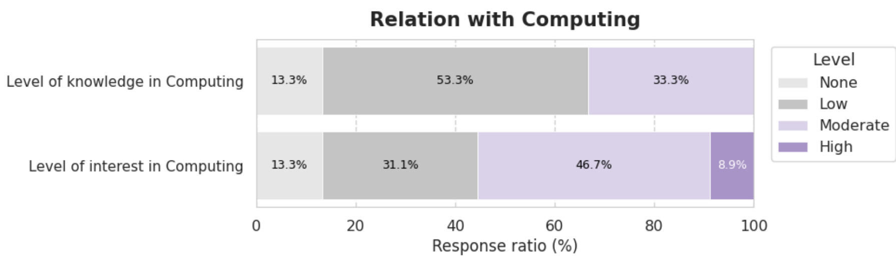

Figure 5. Students' levels of knowledge and interest in Computing.

Analysis of technology and application use (Figure 6) reveals that most students use digital tools primarily as end users rather than as creators of technology. Few have been exposed to programming languages; among these, Python, Java, and JavaScript are the most common. Tools designed for beginner Computing education, such as Scratch,

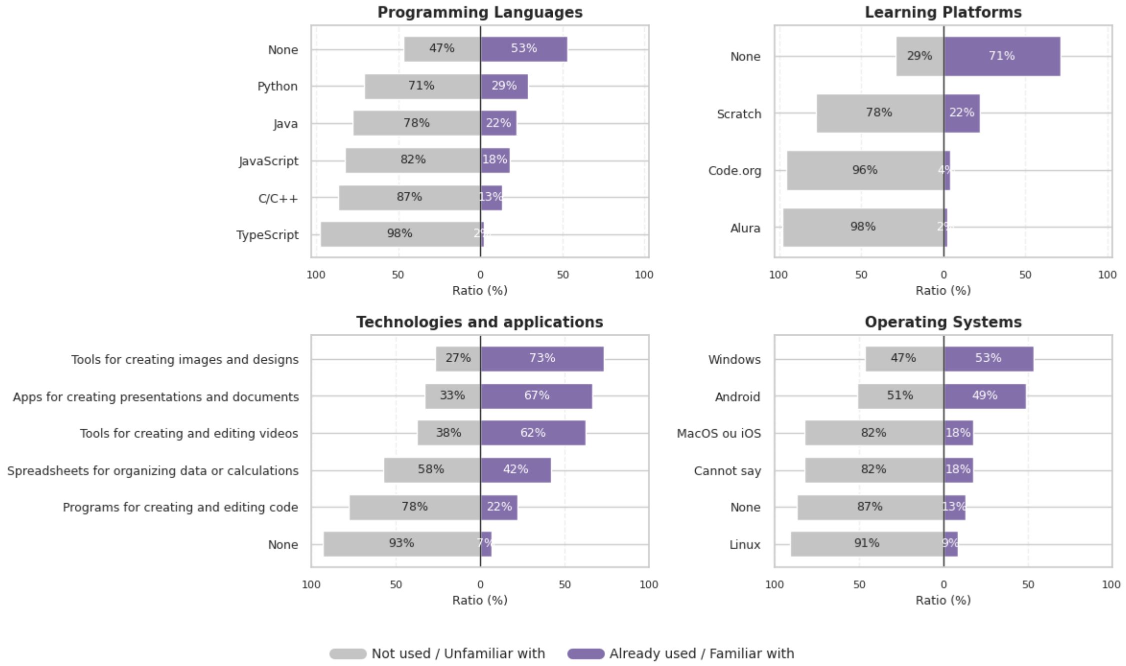

Figure 6. Prior exposure to Computing.

Code.org, and Alura, have low usage rates. The frequent selection of ‘none’ as a response further illustrates the lack of Computing education in basic schooling.

Students exhibited greater familiarity with general-purpose technologies, such as text editors, presentation tools, image editors, and spreadsheets, which are commonly integrated into daily school activities. In contrast, programming or code editing applications remain largely unexplored, resulting in basic proficiency levels. Analysis of operating system usage indicates that most students use Windows or Android, while Linux and macOS are minimally adopted. This disparity further influences the range of technologies to which students are exposed.

Statistical associations among profile variables and indicators of experience and relationship with Computing (Figure 7) and measures of prior contact with the field (Figure 8) highlight persistent inequalities in access to Computing education among ICj students.

Figure 7 indicates that the strongest correlations relate to how often students participate in Computing courses and activities; these are most pronounced for students from specific regions and school grades. Grade level shows a moderate relationship with frequency of contact, suggesting that students in later stages of schooling accumulate greater exposure to Computing. State, family income, and receipt of social benefits show only weak associations, reinforcing that formal Computing experiences remain limited regardless of socioeconomic background.

Figure 8 displays stronger associations in items denoting a lack of exposure, such as ‘No programming language’, ‘No platform to learn programming’, ‘No tool’, or ‘No operating system’. These patterns suggest that insufficient technological opportunities are unevenly distributed across groups, especially among lower-income students, certain

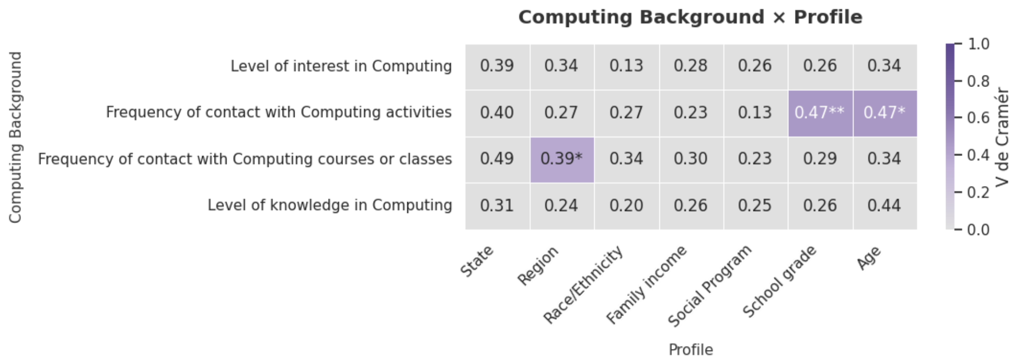

Figure 7. Associations between *Profile* and *Relationship/Experience with Computing*.

racial groups, and those living in specific territories. In contrast, the use of educational tools, such as Scratch, Code.org, and Alura, and programming or code-editing software, along with operating systems like Linux, appears to be positively associated with students from higher-income families, from the South and the Midwest, and those in more advanced school grades.

This analysis demonstrates that socioeconomic, regional, and educational factors continue to determine who can access meaningful technological learning experiences. Consequently, programs that expand girls' participation in STEM must reduce these unequal opportunities by offering experiences that increase their agency in technological and scientific fields.

4.4. Expectations and Professional Aspirations

Students' expectations and professional aspirations (Figure 9) reveal a diverse range of academic interests and varying levels of certainty regarding their future careers. The data show varying degrees of affinity across areas such as Arts and Communication, Humanities and Social Sciences, Biological and Health Sciences, Engineering, and Computing, indicating that the group is heterogeneous in terms of academic inclination. Across all these fields, however, there is a significant number of students still exploring possibilities or with only initial ideas about their career paths, highlighting the importance of guidance, experimentation, and discovery activities, particularly within the context of Computing.

Among students who express interest in Computing and Technology, a substantial portion remains unsure or is still exploring potential professional pathways. Similar patterns appear in areas such as Biological and Health Sciences and Humanities and Social Sciences, suggesting that many participants are still in a phase of experimentation and decision-making. Programming, Artificial Intelligence, Computer Networks, and Robotics emerge as central themes. Cross-cutting topics such as public speaking, academic writing, and design are also valued, indicating an openness to engage with Computing from multiple perspectives.

Associations among profile variables and learning expectations (Figure 10) show how sociodemographic characteristics shape students' educational interests. The strongest associations are concentrated in three variables: receipt of social benefits, family income, and school grade. Students supported by social programs are more likely to prioritize topics such as 'Interface Design' and 'Design and Editing'. Family income is also related

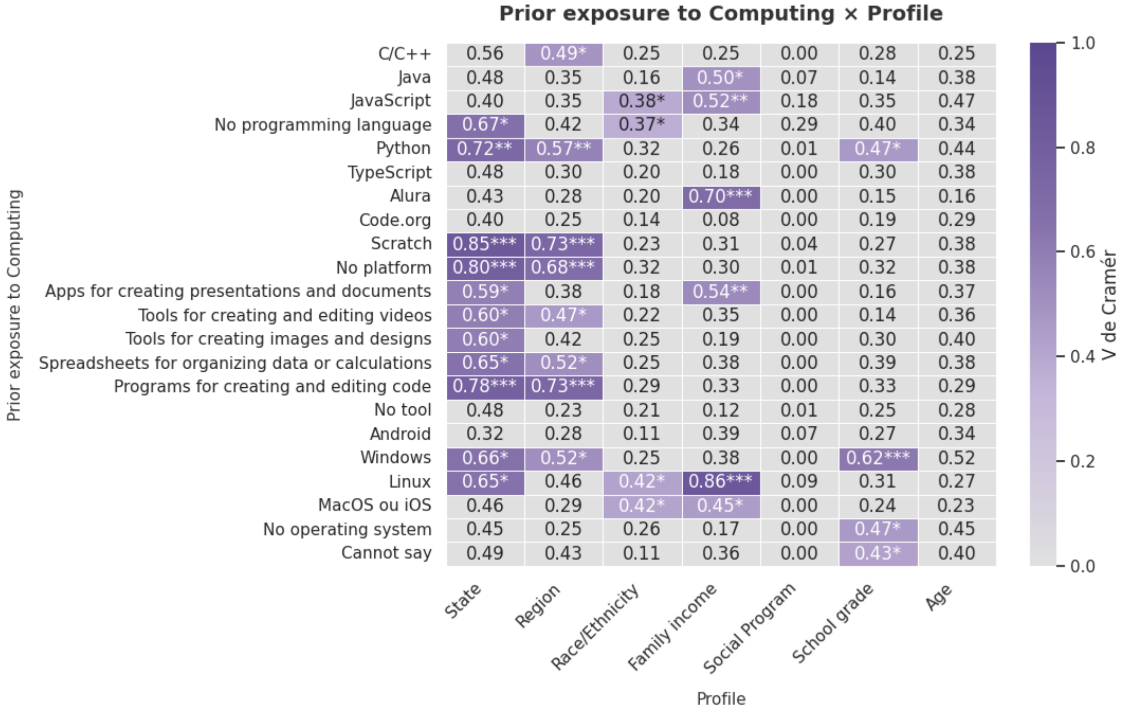

Figure 8. Associations between *Profile* and *Prior Exposure to Computing*.

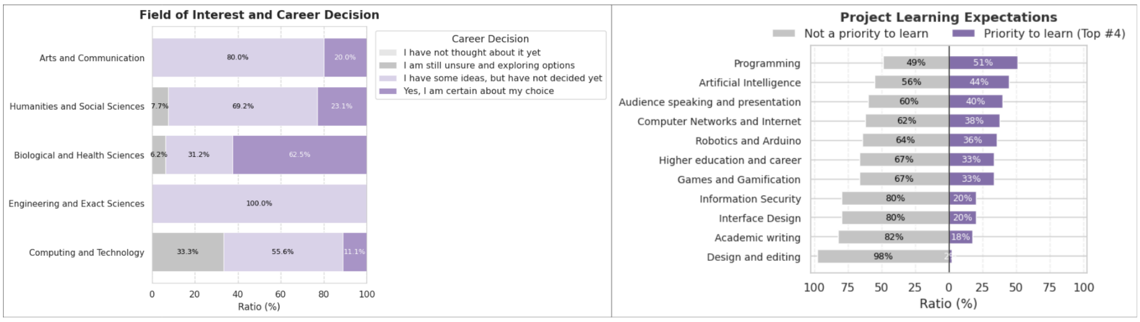

Figure 9. Future expectations of ICj students.

to specific preferences, such as interest in 'Games and Gamification'. School grade further influences learning expectations: interest in Computing is more prevalent among students in the final years of middle school and the early years of high school, while interest in 'Design and Editing' appears exclusively among students in the 8th grade.

These results show that participants' aspirations are shaped not only by individual affinities with Computing but also by socioeconomic conditions and their educational stage. The *RENACEE MD* project, therefore, plays a strategic role in offering experiences that reduce these inequalities, broaden academic and professional horizons, and strengthen girls' sense of belonging in the field of Computing.

5. Discussion

The results presented in this study reinforce that inequalities in access to Computing among girls in Brazilian basic education are structural. Gaps in connectivity and access to devices identified among participants converge with national data from PNAD TIC 2024

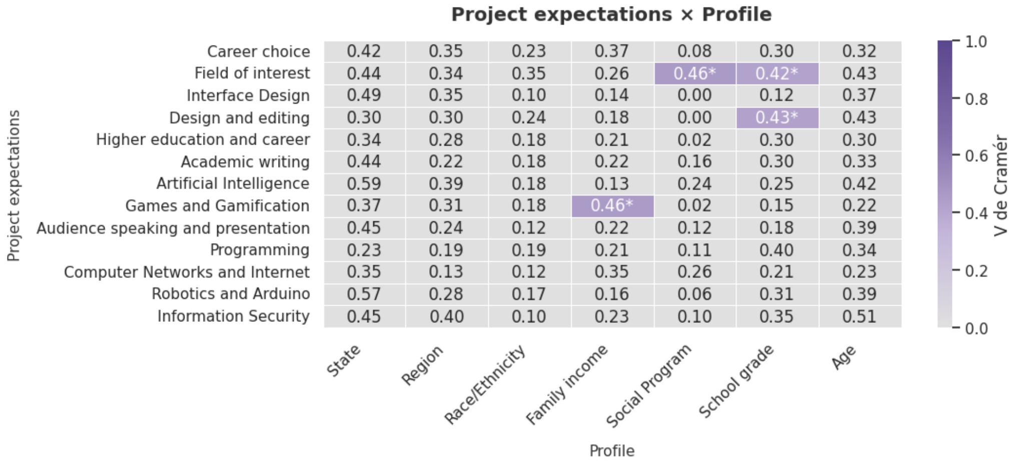

Figure 10. Associations between *Profile* and *Project Expectations*.

and TIC Domicílios 2024 [IBGE 2024, CETIC.br 2024a], which indicate that only 58% of Brazilian households have a computer and roughly 40% rely exclusively on mobile access.

The widespread lack of prior Computing experiences reported by most students also reflects curricular inequalities highlighted by TIC Educação 2024 [CETIC.br 2024b], which shows that fewer than one-third of public schools offer activities related to programming or computational thinking.

The results clearly demonstrate the need for intersectional approaches, as gender, race, income, and territory intersect to produce cumulative disadvantages—an argument also raised by Amaral and Oliveira (2024) and Menezes et al. (2024). The combination of limited access to devices and low familiarity with digital tools indicates that introductory digital literacy strategies are essential, particularly for students with reduced technological repertoires. Activities conducted in school and university laboratories, as well as mobile-accessible tasks, may help mitigate some of these barriers. This view aligns with the gradual progression of computational thinking proposed by Brennan and Resnick (2012) and Grover and Pea (2018).

The data also reveal significant regional and sociocultural differences in student engagement, reinforcing the need for educational practices sensitive to territorial contexts. Literature on culturally relevant Computing [Ashcraft et al. 2017] suggests that locally grounded projects addressing environmental, cultural, or social issues can strengthen students' sense of belonging and make Computing more meaningful for historically underrepresented groups.

From an ethnico-racial perspective, Black and Parda girls are strongly represented among participants, which calls for educational practices that acknowledge and engage with their lived experiences and sociocultural contexts. Studies on Black women in STEM [Ong et al. 2018] indicate that welcoming environments and activities that discuss digital justice, algorithmic bias, and the social role of technology can enhance belonging and relevance. Incorporating moments of critical reflection throughout workshops may therefore strengthen students' technological trajectories and identities.

The analyses also show that lower-income students report lower initial interest and reduced contact with Computing professionals. Prior research consistently demonstrates that the presence of women mentors and role models is crucial for identity development and motivation in the field [Lockwood 2006, Stout et al. 2011]. Mentorship programs involving undergraduate students, researchers, and professionals — especially women from similar regions or backgrounds — may broaden students' perspectives and reinforce Computing's potential as a pathway toward social mobility.

Self-reported interests emerge as a strong predictor of engagement. Studies on girls in STEM show that connecting activities to personal interests significantly increases participation [Msambwa et al. 2024]. Creative, collaborative, and project-based workshops [Israel-Fishelson and Hershkovitz 2024] can further support persistence and cultivate meaningful learning experiences.

The students' intersectional profile should not be understood merely as a set of sociodemographic factors, but rather as an indicator of differentiated educational needs. We highlight several recommendations to strengthen Computing Education practices: (i) partnerships to ensure adequate technological infrastructure and investments in basic digital literacy; (ii) progressive pedagogical pathways that build technological self-efficacy; (iii) learning strategies contextualised to regional realities; (iv) reflective activities on the social role of technology; (v) women mentorship programs; and (vi) actions aligned with students' interests. These recommendations contribute to more equitable outreach and educational practices, aligned with the promotion of girls' inclusion in Computing from an intersectional gender perspective.

6. Conclusion and Future Work

This paper presented an exploratory quantitative analysis of the intersectional profiles of girls in Junior Scientific Initiation Research in the *RENACEE MD* project, highlighting how gender, race/ethnicity, socioeconomic status, and territory intersect to shape girls' engagement and educational trajectories in Computing. The findings show that, although there is substantial interest in the field, structural inequalities continue to limit access to technological infrastructure, prior exposure to Computing, and learning experiences that resonate with students' sociocultural realities.

Empirically, the study demonstrates that diagnosing gendered intersectionalities enables the identification of specific barriers experienced by different groups. Methodologically, the research illustrates the potential of combining descriptive statistics, correlation analyses, and data visualizations to interpret patterns of inequality and inform educational strategies.

The results provide practical recommendations aligned with the challenges of access, belonging, and engagement identified through the intersectional analysis. These recommendations help foster a more inclusive, diverse, and socially committed landscape of Computing education in Brazil. As future work, we intend to qualitatively investigate, together with the coordinators of local activities, the barriers and strategies perceived in the participation and development of ICj students. This triangulation will allow us to understand not only the obstacles encountered but also the strategies for overcoming them that emerge throughout the educational process.

Acknowledgments

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Use of Artificial Intelligence

The authors used ChatGPT (OpenAI), GPT-5 model, as an aid for textual review, clarity improvement, and structural organization of the paper. Methodological and analytical decisions are the sole responsibility of the authors.

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