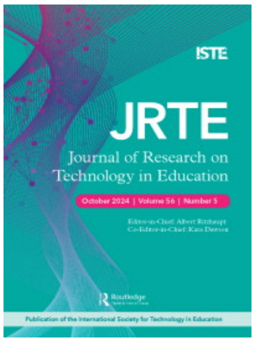

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Gender perspective in the computational thinking program of Uruguay: teachers' perceptions and results of the Bebras tasks

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ABSTRACT

The Uruguayan computational thinking (CT) program promotes CT skills for students in fourth, fifth, and sixth grades. Since 2017, it has reached over 70,000 students, with participation and Bebras challenge performance equally distributed by gender. This study examines gender perspectives in the program, focusing on teacher perceptions, student outcomes, and participation. Positive initiatives to encourage girls' involvement are described. A survey revealed a slight preference among teachers for boys in programming and CT skills. Bebras results showed girls performed equally well, or better, than boys. The findings highlight that while progress has been made toward gender equality in Uruguay's CT program, challenges remain. The fact that girls perform as well as boys is promising. Addressing teacher biases and gender stereotypes can help create a more inclusive environment for all students to develop CT skills.

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Gender; computational thinking; Uruguay; Bebras; Ceibal

Introduction

Women's participation in Science, Technology, Engineering, and Mathematics (STEM) is limited worldwide, especially in fields such as information and communication technologies and engineering, with global female enrollment rates standing at 27% and 28%, respectively (UNESCO SAGA Team, 2017). Increasing the number of women in STEM careers contributes to reducing the gender wage gap, enhancing women's economic security, and ensuring a diverse and talented STEM workforce and avoiding bias in these fields and its products and services (Corbett & Hill, 2015).

Uruguay is not an exception to this phenomenon. The proportion of female university graduates in STEM-related areas face significant challenges especially in Information and Communication Technologies, where women represent only 17.7% of graduates. Statistics from the Universidad de la República reveal that in 2021, women made up 24% of the new students in the School of Engineering (División Estadística - Dirección General de Planeamiento, 2022). This data is representative of the larger trend in the country's higher education sector because it accounts for 87.1% of all university enrollments that year (División Estadística - Dirección General de Planeamiento, 2023).

Women's distance from education in STEM fields correlates with their underrepresentation in the labor market. This disparity leads to what is known as horizontal segregation in the labor market, meaning women tend to be concentrated in sectors like education and healthcare while being underrepresented in STEM fields (Bello, 2020). In Uruguay in 2020, the information and

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communication technologies sector was composed of 70.4% males and 29.6% females. Moreover, according to 2017 data, women researchers in engineering and technology represent only 36% of researchers in these areas in the country (Bello, 2020). Meanwhile, sectors like education, social services, and health services showed a majority of women, with proportions exceeding 73.6% and 75.4%, respectively (Reynaud & Semblat, 2020).

In addition, a notable lack of women persists in leadership and decision-making positions across academic and professional sectors, a phenomenon referred to as vertical segregation (Bello & Estébanez, 2022). In this sense, the most significant disparities in gender participation within Uruguay's STEM landscape are clearly evident in roles such as director or department manager, where 32% of men hold these positions compared to only 15% of women (Mesa Interinstitucional Mujeres en Ciencia, Innovación y Tecnología, 2020).

Literature review

Gender is a social category that begins to be constructed in early childhood. It is a factor that children use to categorize themselves through comparison with their peers (Renno & Shutts, 2015). This comparison begins in the preschool years and is reinforced through interactions between children and adult referents (Ruble et al., 2006). Importantly, children begin to become aware of these gender labels between the ages of two and three (Mulvey et al., 2010). Gender stereotyping in relation to STEM skills begins between the ages of three and five, as girls receive limited support from reference adults to engage in STEM activities (Mulvey & Irvin, 2018). This leads to the understanding that gender stereotypes in STEM are influenced by cultural and social factors that influence early socialization and can reinforce fixed beliefs about children's abilities. These include preconceived notions and prejudices that associate certain roles, skills and characteristics with particular genders. STEM fields are often presented as more appropriate for men, resulting in fewer women pursuing STEM studies and careers (Bian et al., 2017; Bordalo et al., 2019). The absence of women in STEM areas contributes to perpetuating gender roles and stereotypes that influence girls and boys in their educational process, significantly impacting their later career decisions (González, 1999; Hammond et al., 2020).

At the individual level, personal preferences, aspirations, and self-perceptions of abilities play a significant part in shaping decisions regarding STEM education. Subconscious associations drive gender stereotypes, contributing to the underrepresentation of women and minorities in STEM fields (Asplund & Welle, 2018). Even merit alone doesn't shield against cultural bias, emphasizing the need to address implicit biases to foster diversity in STEM (Asplund & Welle, 2018). Individuals' abilities, self-perceptions, and active participation in class are intricately intertwined, influencing their engagement in the classroom setting (Cooper et al., 2018).

On a broader societal level, family and school contexts, along with expectations and attitudes instilled within the family, as well as teachers' perceptions and choices, collectively shape career trajectories and perceived capabilities (Robano, 2023). Gender biases can also impact the performance of boys and girls, particularly in subjects like mathematics, where the prevailing belief suggests that boys outperform girls (Tiedemann, 2000). This bias may persist due to mechanisms like the self-fulfilling prophecy among teachers, a belief or expectation that causes itself to become true due to the behavior it generates. In this context, if teachers believe boys outperform girls in subjects like mathematics, they will do so because their expectations influence their behavior and interactions with students, reinforcing the belief (Jussim, 1989). This bias is fueled by ongoing horizontal segregation in education and the workplace (Jussim, 1989). These biases perpetuate the stereotype that men excel in STEM fields while women thrive in humanities and people-centered areas (Charles & Bradley, 2009).

In addition to gender disparities in STEM education, socioeconomic factors intersect and make us pay special attention to its effect on educational gaps. Recently, the socioeconomic gap in education has widened, resulting in disparities in academic performance that favor higher socioeconomic levels over lower ones (Mckenzie, 2019). The socioeconomic divide acts as a catalyst for the digital divide, a concept that can further exacerbate educational disparities in an increasingly technological world, especially for children from lower socioeconomic backgrounds (Sulkunen, 2013). In response to these challenges, the integration of technology in education has become an imperative, with technology serving as a facilitating tool for learning skills and competencies (Laurillard, 2008).

In response to these multifaceted challenges, integrating technology into education has become imperative. In Uruguay, Ceibal, a public policy program founded in 2007, has the mission of promoting innovative and inclusive education, in tune with emerging technological opportunities, to enhance the development of the learning potential and creativity of each student, with a view to global citizenship. Through this policy, personalized access to digital devices is provided to all children in Public Education, representing a significant milestone in reducing the digital divide (Cobo & Montaldo, 2018). In 2017, Ceibal initiated the Computational Thinking (CT) program with the purpose of promoting the development of skills associated with computational thinking in students from fourth to sixth grade of Primary Education.

The article aims to provide a descriptive review of the Ceibal CT program, focusing specifically on its strategies for fostering gender-inclusive learning environments. To this end, teachers' perceptions of learning computational thinking skills will be examined to determine whether gender-based differences exist. At the same time, the article will analyze the results of the Bebras 2022 (Plan Ceibal, 2022) tests to assess the performance of boys and girls and the impact of their participation in the CT program. Through these analyses, the article aims to identify the strengths and challenges of the program in view of continuous improvement of the program's quality for teaching and learning.

Ceibal computational thinking program

Initiated in 2007 by a presidential decree in Uruguay, the Ceibal[1] has established itself as an innovative model that provides every student and teacher in the public education system, from first grade of primary school to the third year of secondary school, with technological devices such as laptops or tablets. This program has been key in closing the technological gap, reducing the disparity in access to technology from a difference of 13 times between the most and least favored deciles in 2007 to just 1.2 times in 2010, a level that has been maintained to date.

Ceibal works in partnership with the National Administration of Public Education (ANEP, by its acronym in Spanish) and has woven technology with education through a variety of resources and programs. Among these are learning platforms for mathematics like Aleks and Matific, CREA (name in Ceibal Uruguay for Schoology[2]) for educational resources, robotics and programming competitions, computational thinking initiatives, tools like micro:bit boards and 3D printers, as well as an English teaching program using video conferencing.

In addition to providing equipment, Ceibal ensures internet connectivity in all public educational institutions in the country. It has established a high-quality video conferencing network in 1,650 educational centers, covering 100% of urban establishments and benefiting 97% of the public student population. Thanks to the installation of high-quality equipment and fiber optic, real-time teaching sessions are conducted without delays, facilitating the effective implementation of programs such as Ceibal in English and Computational Thinking, through the remote participation of teachers.

Since 2017, Ceibal has been implementing a Computational Thinking program, which started with a pilot in 30 urban public schools and, by 2022, had expanded to include nearly 2,600 groups, 50,000 students, and 2,100 classroom teachers across almost 65% of the country's urban public schools.

The program, which Ceibal introduced, targets fourth to sixth graders in primary education and is designed to enhance skills related to Computational Thinking. Participation in the program is voluntary and extracurricular, allowing teachers to opt in if they consider it beneficial for their students. The instructional sessions, conducted once a week for 45 min *via* video conference during the regular school hours, involve a collaborative teaching approach between a remote instructor and the in-class teacher.

Specifically, the program works on dimensions of computer sciences, and skills. The dimensions are: Data Structures, Algorithms and Devices, Impacts on Society, Computational Problems. The main skills include: (1) Generalization: Identifying and applying common solutions to different problems in different contexts. (2) Abstraction: Interpreting problem data by recognizing relationships between variables. (3) Algorithmic thinking: the ability to generate an orderly and deep programming sequence that leads to the solution of the problem. (4) Evaluation: Evaluate the efficiency and effectiveness of the solution, modifying algorithms and code as necessary. (5) Decomposition: Breaking down a complex problem into manageable segments, organizing these elements and delineating the negative and positive facets of the problem (Dagienė & Sentance, 2016; Goyeneche et al., 2021). Additionally, it also promotes reading and writing skills, analysis and problem-solving, flexibility, exploration, and curiosity.

The curriculum is project-based, this methodology proposes an active, student-centered and inclusive learning style. It also requires a strong social load, since learning is shared among peers, thus learning is considered more meaningful. It is important to emphasize the interdisciplinary nature of this methodology, which allows the integration of computational thinking with other fields of knowledge. The curriculum covers the entire academic year and has didactic sequences that scaffold each project, and combine CT with other areas of knowledge, such as Mathematics, Science, as well as Language, Literature and Physical Education, among others, which illustrate the interdisciplinary approach of the program.

These projects introduce students to computer science and programming, developing skills in expression, logical reasoning, algorithmic thinking, abstraction, and problem-solving Ceibal (2022).

Ceibal's Computational Thinking team also run the Bebras Challenge[3] in Uruguay, motivating the teaching community to take part in the contest. In particular, the schools included in the program are encouraged to participate. In this way, we can continue to develop computational thinking skills, as well as observe the students' performance in the proposed items.

The gender perspective across computational thinking program

To address the gender gaps and inequalities that prevail in the STEM field, the CT program incorporates a gender perspective in its educational strategy. To this end, remote teachers are trained and pedagogical practices are developed to promote gender equity.

Ceibal incorporates different strategies in the didactic guides aimed at highlighting and denaturalizing gender biases. For example, one approach is through role models. In cases where the pedagogical proposal includes a main character linked to computer science or science, a female representative is chosen (examples: Ada Lovelace, Ida Holz, or young professionals from the local community).

Another example is direct instruction during distance teacher training sessions and informational texts included in each of the lesson plans. These texts advocate "Promoting an inclusive educational experience that fosters gender equality and systematically challenges the stereotype of computer science as an exclusively male domain. Our goal is to encourage girls' participation and equip them with the necessary tools, such as attention, support, and positive feedback, among others" (Sample message in the lesson plans).

Also Ceibal's Computational Thinking team monitors the quality of the teaching and learning process in CT classes by recording and observing a sample of the classes taught each year. The objective of monitoring the quality of the CT classes is to establish a systematic methodology for evaluating the teaching/learning process, always seeking continuous improvement. This involves observing the classes using an instrument that allows quantitative and qualitative evaluation of each remote teacher in the sample, giving them feedback and follow-up during the school year.

The observation as an evaluation instrument focuses on four dimensions: responsibility, commitment, deep learning and gender. It is important to note that compared to the rest of the dimensions observed, the gender dimension is the one that is evaluated the lowest by the monitoring team.

Regarding the gender dimension, teachers are expected to pay special attention to the participation of female students, as well as to value their contributions and encourage them to share them with the group. In this sense, remote teachers are expected to:

- Foster an inclusive and equitable educational environment and specifically one that actively promotes gender-inclusive education.
- Takes intentional steps to design activities and provide spaces that specifically encourage and facilitate the active participation of female students during class.
- Intervene in situations where gender stereotypes are perceived to limit girls in their actions.

Particularly, the Observation/Evaluation Instrument assesses remote teachers by observing a recorded class and evaluates the following:

- Female students actively participate.
- The remote teacher generates and promotes participation opportunities for female students.
- Female students perform activities independently and ask questions when they have doubts or difficulties.
- The remote teacher is equitable in granting turns and encourages female students to participate.
- Female students present their products and can reflect on their problem-solving process.

According to this monitoring tool, the monitoring team has detected challenges given the lack of specific promotion of girls' active participation by distance teachers, as well as the effective participation of girls in classes. To improve gender equality in STEM, it is crucial to recognize that seeking equality between boys and girls alone is insufficient as we must not overlook the profound challenges faced by girls in science and technology fields. These challenges have to do with addressing deep-seated biases and systemic barriers. Therefore, efforts to achieve equitable participation must be multifaceted, addressing quantitative and qualitative disparities to truly empower girls in STEM.

Active involvement and recognition of girls by teachers and peers are key steps toward breaking down these barriers, narrowing the gender technology gap, and fostering equity. Therefore, it's imperative for the area of quality monitoring in computational thinking classes to prioritize the promotion of girls' participation.

Methodology

The present study applies a descriptive approach to explore teachers' perceptions of student abilities, with special attention to the identification of gender biases. It proposes a comparative analysis of students' performance disaggregated by gender in the Bebras challenge. Teacher's surveys since the start of the program in 2018 have indicated a recurring perception of higher programming skill among boys. Analysis of the 2022 Teacher Satisfaction Survey was selected to contrast these perceptions with results obtained in the Bebras challenge of the same year, using a representative sample of sixth-grade students collected in 2022. This study focuses on gender biases among teachers participating in the CT 2022 program and conducts a thorough analysis of the Bebras results, segmented by gender, to detect differences and assess other relevant variables. The objective is to deepen the understanding of the situation, and shed light on practices to improve the program in terms of the gender gap.

Participants and procedure

Teachers perception survey: designed by Ceibal, and around the CT program, every year since 2017, a survey is carried out to understand teachers' experiences with the program. Teachers have the option to complete this survey at the end of each year. The first section gathers socio-demographic data, followed by questions regarding participation in the program and levels of satisfaction. The final section inquires about participants' perceptions of their proficiency in various skills related to the program, including programming, problem-solving, teamwork, organization, result evaluation, acquired knowledge, class participation, use of CREA (Learning Management System), and interest in their students' learning. These final questions are asked separately for boys and girls. For this research, we will use the teacher survey, run in 2022, conducted *via* the SurveyMonkey platform, which was sent to 2,222 elementary school teachers enrolled in the Computational Thinking program. A total of 877 teachers responded, of whom 781 provided complete responses concerning gender dimensions.

Bebras

We examined the 2022 results of the Bebras Challenge in Uruguay. For this edition, three categories participated in the challenge, with students from third grade of elementary school to third grade of high school. The focus will be on a representative sample of sixth grade students who have participated in the Computational Thinking program and those who have not been part of it. The Bebras sample consists of a two-stage probability sample representative of enrollment in the sixth grade computational thinking program. In the first stage, centers were drawn with probability proportional to enrollment in the computational thinking program, and in the second stage, up to three groups were selected within the center, divided into groups with CT and groups without CT. To obtain the student weights, the center and group weights were taken into account (wStudent = wCenterj * wGroupk).

Measures

Students level of competencies acquisition: such as programming, problem-solving, teamwork, organization, evaluation of results, acquisition of new knowledge, participation in class, use of the CREA learning environment, and interest in learning is assessed through the categorical perception ("very high (1)," "high (2)," "medium (3)," "low (4)" to "very low (5)") of the teacher regarding the acquisition of these competencies by their students. Each of these competencies is addressed in a separate question for both girls and boys. The theoretical response range is from 1 to 5 points, with the option of NS/NR (No Statement/No Response). For ease of interpretation and comparison, it was decided to group the high and very high categories on the one hand, and the low and very low categories on the other.

Gender gap in hetero-perception: this term refers to the variance in responses across different dimensions for girls and boys. For instance, if a teacher rated girls as "medium" (= 3) and boys as "high" (= 2), the resultant difference would be $3 - 2 = 1$. Here, positive values indicate that boys are rated higher by their teacher, whereas negative values suggest girls receive higher ratings. The theoretical response range spans from −4 to +4 points. Upon calculating this score, it was observed that in some instances women scored higher, in others men scored higher, and sometimes the scores were identical for both genders. Teachers who selected "Don't Know/No Response" (DK/NR) were excluded from the analysis of this variable.

Computational thinking skills: these scores represent the results obtained in the Bebras challenge. The Bebras 2022 (Plan Ceibal, 2022) challenge consists of 14 questions to be answered, each correct answer being worth 1 point and each incorrect answer being worth 0 points, as the a priori difficulty of each question was not taken into account. As a result, the theoretical range of scores varies from 0 to 14.

Sociocultural context: The Sociocultural Context Level is constructed by dividing all public schools into five equally sized groups, known as quintiles. Quintile 1 encompasses the bottom 20% of schools located in the most vulnerable socioeconomic contexts, whereas Quintile 5 comprises the top 20% of schools in the least vulnerable contexts (ANEP, Monitor educativo[4]).

Results

To conduct all the statistical analyses for this research, the academic software JASP (JASP TEAM, 2023) and R (R Core Team, 2022) were used.

Teacher perceptions by gender: analysis from teacher surveys

Among all the teachers surveyed, 94.1% were females. Regarding grade distribution, 56% taught fourth grade, 28.4% taught fifth grade and 35.9% taught sixth grade. Of the total number of teachers surveyed, 22.8% belonged to schools in the sociocultural context of quintile 1, 17% to quintile 2, 15.4% to quintile 3, 19.5% to quintile 4, and 24.2% to quintile 5.

In reviewing teachers' perceptions of girls' skills, as shown in Figure 1, most consider them highly skilled in areas, such as using CREA (71%), teamwork (67%), interest in learning (63%), organization (59%), and knowledge acquisition (55%). However, in specific areas such as programming, only 44% of teachers consider girls' programming skills high, slightly below 46% who consider them having medium skills. This trend persists in problem solving skills, with 43% of teachers considering girls' skills high, compared to 48% who perceive them as average. Furthermore, in performance assessment, 42% of teachers rate girls' skills as high, while 49% rate them as having medium skills.

When asked about boys, more teachers perceive them as having high rather than medium programming skills, as illustrated in Figure 2. Boys are generally perceived as having high proficiency in programming (58%), problem solving (49%), teamwork (53%), knowledge acquisition (54%), class participation (52%), use of CREA (65%) and interest in learning (59%). Besides, when it comes to organization and evaluation of results, the frequency of teachers who consider boys to have medium skills is higher than those who consider them to have high skills, with 49% and 40%, respectively.

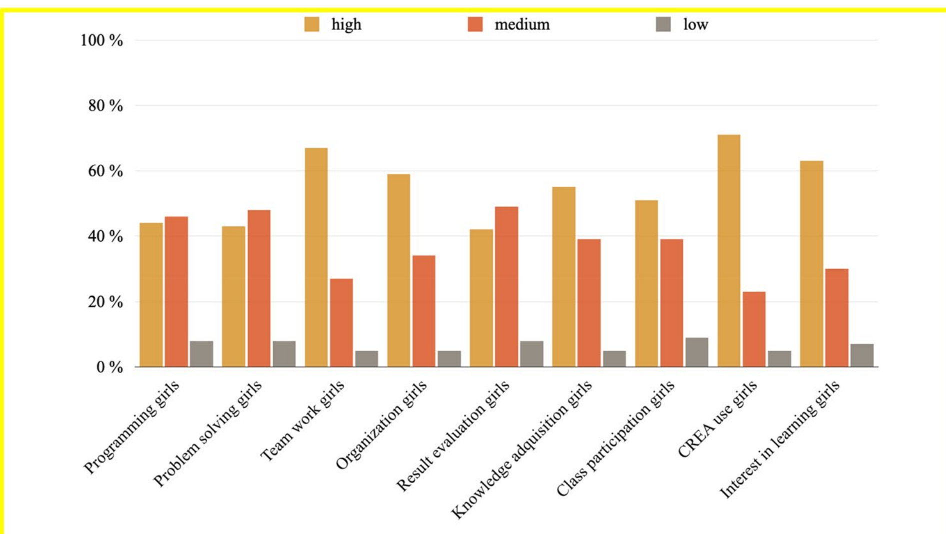

Figure 1. Teacher perceptions of girls' skills. *Note*: 1–2% of responses were DK/NR. Source: Data from the 2022 Teacher Satisfaction Survey; figure created by the authors.

When comparing teachers' perceptions of their students by gender, as evidenced in Figure 3, we find aligned conclusions regarding the skills in which girls and boys are perceived to excel. We observed that 74% of the teachers surveyed perceived differences by gender in at least one skill. However, it is important to note that, in each skill assessed, more than 50% of teachers observed equal skill levels between boys and girls. The highest proportion of teachers who perceive equality between girls and boys is in the use of CREA, with 74.1%. In contrast, the lowest proportion of teachers who perceive boys and girls as equal is found in class participation (55.2%), organization (56.2%) and programming (58.1%).

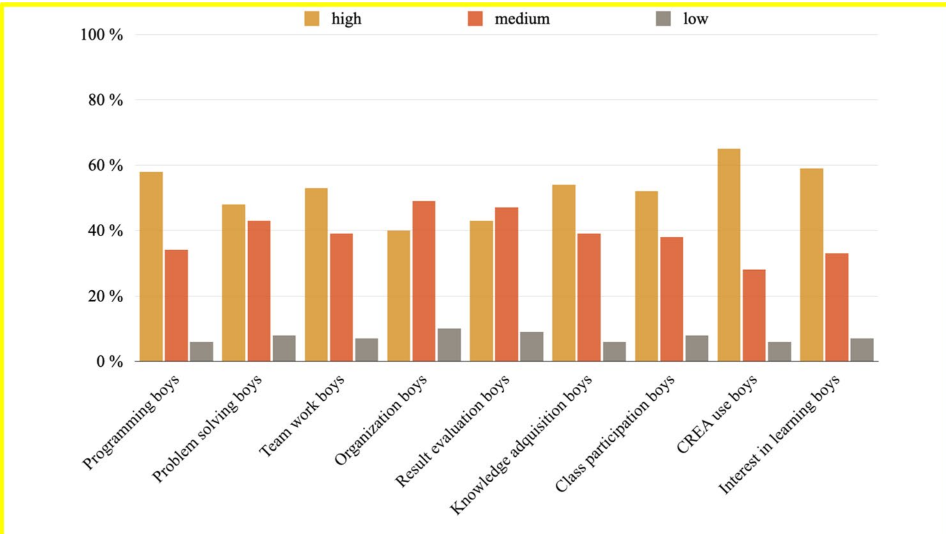

Figure 2. Teacher perceptions of boys' skills. *Note*: 1–2% of responses were DK/NR. Source: Data from the 2022 Teacher Satisfaction Survey; figure created by the authors.

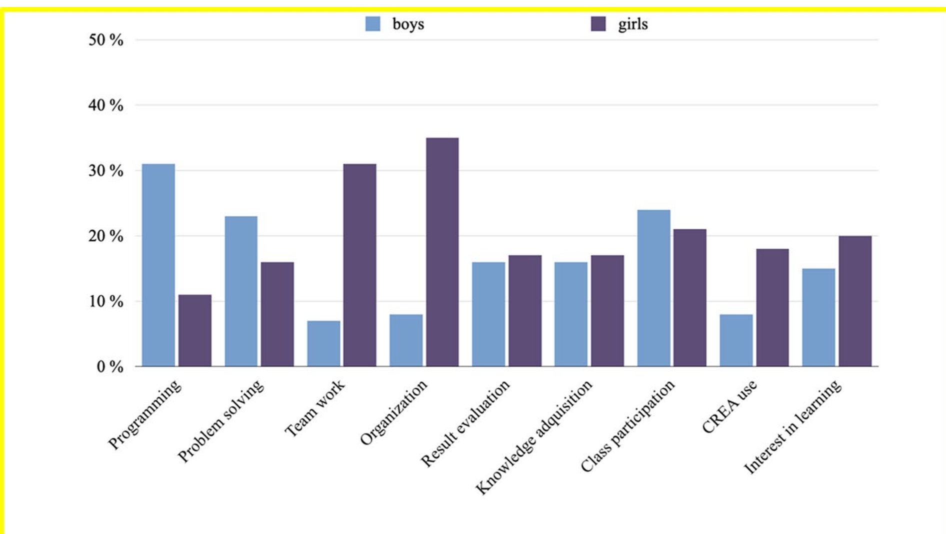

Figure 3. Teacher comparative perception of skills between boys and girls. *Notes:* for better visualization, the scale is up to 50%. The proportion of teachers who have an equal gender perception of these skills is omitted. Source: Data from the 2022 Teacher Satisfaction Survey; figure created by the authors.

From the data, we observe that boys are viewed as having higher skills than girls in programming, problem solving, and participation during computational thinking classes. While girls are often seen as better than boys in team work, organization, result evaluation, knowledge acquisition, the use of CREA and interest in learning.

It is important to note that the most significant difference in positive perception toward boys is observed in the area of programming, while the greatest disparity toward girls is related to organizational skills. Results evaluation and knowledge acquisition have similar frequencies of teachers perceiving boys as better or girls as better (one percentage point in favor of girls).

Finally, we explored whether teachers' perceptions of students' abilities varied as a function of teachers' gender, the sociocultural context of the school, and the location of the school in urban or rural areas. Overall, no significant differences were found. However, due to the low representation of male teachers, findings on this group are limited. Although most skills showed no significant disparities between sociocultural levels, differences were observed in specific skills. For example, it was observed that among teachers with groups in quintile 5 there were more teachers with perceptions that girls are better at organizational skills than for the rest of the quintiles. Also, in terms of teamwork skills, fewer teachers perceived boys to be better than girls in quintile 4 compared to the other quintiles. Despite these differences, the biases toward girls or boys by ability remained with the same sign across all socioeconomic quintiles. In addition, no significant differences were found according to school location, although rural schools were notably less represented than urban schools.

Computational thinking skills: analysis from Bebras

This section presents a descriptive analysis of the results obtained from a controlled sample in the 2022 Bebras challenge in Uruguay. It is noteworthy that the statistical tests performed throughout the section use the sample weights of each individual.

The sample consists of a total of 3,889 Uruguayan sixth grade elementary school students. Among them, 1,844 participated in the 2022 CT program edition, and 2045 did not.

From the total number of students who participated in Bebras, girls constituted 47% and boys 53%. Among the girls, 52% were not enrolled in the CT program, while 48% were. On the other hand, of the male participants 53.2% were not part of the CT program, while 46.8% were. Finally, the distribution among sociocultural quintiles of those who took the test, 18% belonged to quintile 1, 13% to quintile 2, 19% to quintile 3, 22% to quintile 4 and 28% to quintile 5. Examining gender and quintile in Table 1, we can observe slight percentage differences within the CT and non-CT groups according to gender.

When examining the Bebras results, the average score obtained was 6.2 out of 14, with a median score of 6. The results of a mean comparison test indicate that participation in the CT program significantly positively influences Bebras scores, as participants achieve an average score of 6.4 compared to 6.1 for non-participants.

Furthermore, when analyzing Bebras challenge scores by gender, regardless of CT participation, our investigation revealed statistically significant differences favoring girls over boys, as confirmed by a t-test ($t = 3.09$, $p < .00$). Specifically, girls scored an average of .21 points higher than boys.

$$girls\,\underline{x} = 6.37\left(sd = 2.26\right), boys\,\underline{x} = 6.16\left(sd = 2.36\right).$$

Table 1. Distribution of Participating Children by Quintile, Stratified by CT Enrollment.

	CT		No CT	
Quintile	Girls	Boys	Girls	Boys
1	13%	14%	22%	24%
2	14%	15%	11%	12%
3	11%	11%	26%	26%
4	29%	32%	15%	16%
5	33%	29%	26%	23%

The difference in mean scores obtained by girls compared to boys is greater when both groups have participated in computational thinking (CT) classes, as can be observed in Figure 4. For girls and boys who have participated in CT classes, the difference in mean scores is −0.28 (girls to boys).

$$girls\,\underline{x} = 6.55(sd = 2.27), boys\,\underline{x} = 6.27(sd = 2.38).$$

While in the case of those who have not participated in CT classes, the difference in mean scores is −0.15 (girls to boys). Therefore, the difference is greater in the group that has participated in CT classes.

$$girls\,\underline{x} = 6.21(sd = 2.24), boys\,\underline{x} = 6.06(sd = 2.34).$$

Sociocultural background significantly affects the performance of participants in the challenge, with lower scores observed among students from the lowest sociocultural quintiles compared to the highest. When testing sociocultural levels (quintiles) and Bebras scores, we identified significant mean differences ($F = 40.22$; p value $< .00$). Upon examining Table 2, key findings include: (a) Quintile 1 scores significantly lower than the others. (b) No significant differences were found between quintiles 2, 3, and 4. (c) Similarly, there are no significant differences between quintiles 3 and 4. (d) Quintile 5 scores significantly higher than the others.

Finally, when analyzing, jointly, gender and quintile differences, as illustrated in Figure 5, the results reveal significant insights into the intersection of these factors, we obtained that:

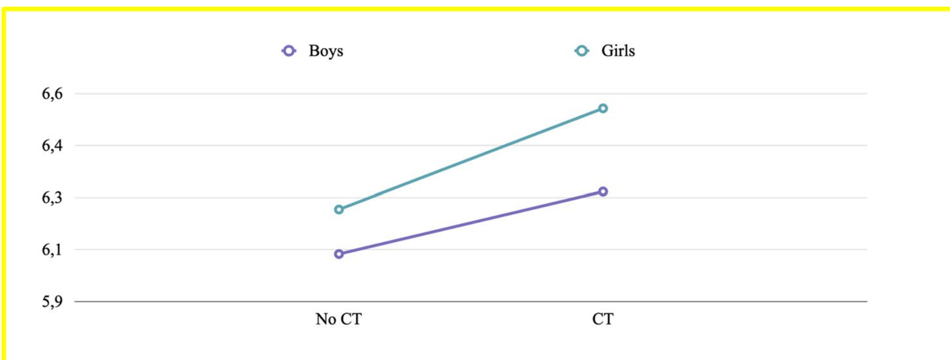

Figure 4. Bebras scores by gender and CT participation. *Note:* The y-axis scale is from 5 to 8 in order to focus on the mean differences studied; however, the possible results are from 0 to 14. Source: Bebras Sample 2022; figure created by the authors.

Table 2. Post Hoc Scores by Quintile.

		Mean diff.	SE	t	Cohen's d	Pbonf
1	2	−0.61	0.12	−5.04	−0.09	<.001
	3	−0.74	0.11	−6.59	−0.11	<.001
	4	−0.75	0.11	−6.84	−0.11	<.001
	5	−1.38	0.11	−12.62	−0.20	<.001
2	3	−0.13	0.12	−1.02	−0.02	1
	4	−0.14	0.12	−1.16	−0.02	1
	5	−0.77	0.12	−6.36	−0.11	<.001
3	4	−0.02	0.11	−0.14	< −0.00	1
	5	−0.64	0.11	−5.79	−0.09	<.001
4	5	−0.63	0.11	−5.75	−0.09	<.001

Notes: When examining the results by gender in the Bebras challenge across all socio-cultural quintiles, it's evident that girls outperform boys consistently, though more prominently in certain quintiles than in others. In this sense, participation in the CT program significantly enhances the average scores of the lowest-income quintile, particularly among girls.

Figure 5. Bebras scores by gender and CT no participation (left) and participation (right). *Note:* The y-axis scale is from 5 to 8 in order to focus on the mean differences studied; however, the possible results are from 0 to 14. Source: Bebras Sample 2022; figure created by the authors.

Table 3. Weighted t-Test Scores by Gender and Sociocultural Gap.

	Mean difference	t	SE	*p*	Cohen's d
No CT (girls Q1 - boys Q5)	1.50	−7.20	.21	<.001	−0.22
CT (girls Q1 - boys Q5)	0.70	−2.90	.24	<.001	−0.10
Girls Q1(CT) - boys Q5 (no CT)	0.62	−0.19	.23	<.001	−0.09
Girls Q1 (no CT) - boys Q5 (CT)	1.59	−7.06	.22	<.001	−0.23

Note: Q1: quintile 1; Q5**:** quintile 5.

a. The greatest difference occurs when comparing girls in the first quintile and boys in the fifth quintile within the context of no computational thinking classes. The maximum difference between these two groups is 1.50 points. Additionally, the effect sizes in these cases can be considered moderate to large, as depicted in Table 3.
b. When girls from the first quintile participate in the Computational Thinking program, the differences in the means drop to 0.62 compared to boys from the fifth quintile who do not have CT classes and to 0.70 when they do have a CT class. In turn, the effect sizes also drop considering them as small to moderate as indicated in Table 3.

Discussion and final remarks

This article provides insight into the persistent gender stereotypes and biases in society that are also prevalent in education and visible in STEM fields. One of the objectives of Ceibal's Computational Thinking Program is to seek continuous improvement in the quality of the teaching and learning process. Within this improvement, there is a policy of focusing on the gender perspective due to the existing gender gap in STEM fields.

The analysis shows that teachers participating in the program have different perceptions of their students' abilities according to gender. They perceive that boys are more skilled in programming, problem solving and active participation. On the other hand, they tend to perceive girls as better than boys at organizational skills, teamwork, and learning to learn. In this line, findings from teacher surveys suggest that boys are more active than girls in CT classes. Aligned with this perception, the computational thinking (CT) monitoring team observes low participation of girls in CT classes.

These findings are consistent with authors who link educational skills to gender stereotypes in society (Gavaldón, 1999; Suter, 2006). On a societal level, hard sciences have historically been associated with men, while the humanities and arts have been associated with women's abilities (Hill et al., 2010). Teachers are no strangers to this context, but their perceptions can be detrimental to both girls and boys (Jussim, 1989). Teachers are not exempt from the gender stereotypes that are prevalent at the societal level, even among those who consciously reject them (Hill et al., 2010). Their perceptions can have negative consequences for both female and male students, affecting, for instance, girls' confidence, and self-efficacy, leading to diminished motivation toward STEM disciplines (Cooper et al., 2018). These perceptions significantly influence the career choices of both genders, contributing to the persistent under-representation of women in STEM fields (Hammond et al., 2020; Schomer & Hammond, 2020). In fact, there are studies that confirm the nonexistence in the acquisition of skills related to their learning (Chongo et al., 2020; Sun et al., 2022), which emphasizes the need to set aside these gender stereotypes in order to reduce or eliminate the existing gender gap in this field.

In addition, the descriptive analysis suggests that teachers' perceptions related to programming and problem-solving are not reflected in the results obtained by students on the Bebras test, where, on average, girls outperform boys in their test scores. In this sense, we find two encouraging results within the Bebras test: first, participation in the CT program improves the performance of both genders in the challenge, and second, girls show a slight improvement compared to boys when participating in it. As a caveat to the study, it should be noted that although a study was conducted to check the internal consistency of the Bebras challenge (Urruticoechea et al., 2023) with acceptable results, the skills assessed by the Bebras items were not validated and the purpose of the challenge was to promote computational thinking at an early learning age, not to assess the skill level of the children. Therefore, conclusions about the level of acquisition of these skills may not be generalizable to the rest of the participants in the computational thinking program.

Results provide valuable insights into the complex interaction between participation in CT program, gender and sociocultural background on development of CT skills in the context of the Bebras 2022 (Plan Ceibal, 2022). The differences in the results obtained by girls and boys on the Bebras test, according to sociocultural quintiles, highlight the importance of participating in the CT program, especially among students from lower socio-cultural backgrounds. This underlines the need to promote CT education initiatives in schools.

Girls from socioeconomically disadvantaged backgrounds may encounter more profound obstacles in accessing and thriving in computational thinking (CT) education, unlike their peers from more affluent sectors. This disparity often originates from a constellation of factors, such as limited access to educational resources, reduced technological exposure, and entrenched societal norms regarding gender roles. Therefore, the participation of these girls in initiatives like the Bebras competition and computational thinking programs is particularly noteworthy. More participation in such programs helps to reduce both gender and socioeconomic gaps, by providing equitable opportunities and fostering an inclusive environment where diverse talents can thrive.

The varied impact of CT education across different sociocultural and gender demographics underscores the urgent need for bespoke educational strategies. It's imperative that education policies and programs are thoughtfully crafted and adaptable, to meet the distinctive needs of students from diverse backgrounds.

Ultimately, grappling with the complexities of gender and sociocultural dynamics in CT education is crucial. It fosters not only a narrowing of the digital divide but also cultivates a generation of technologists who are diverse, equitable, and inclusive. Such an approach mirrors the complex, layered nature of our society and propels us toward a more inclusive future in the realm of technology and beyond.

Finally, it was found that the gender differences perceived by teachers in programming and problem solving as assessed by Bebras were not real. This may be due to the methodology of the program, which does not focus exclusively on teaching these skills and encourages the development of cross-curricular skills such as reading, writing, analysis, flexibility, exploration, and curiosity. It must be taken into account that to perform the Bebras challenge, it is necessary to have good comprehension and reading skills, abilities that women tend to have higher performance (Stoet & Geary, 2018).

Future research

Based on this first analysis of the CT program from a gender perspective, the importance of continuing to conduct the teacher satisfaction surveys and the Bebras sample becomes evident. It is hoped that a representative sample of teachers' perceptions can be made, as well as a controlled sample of Bebras. The accumulation of multi-year data would facilitate comparative analyses, allowing us to discern changes in teacher perceptions and their impact on student performance on the Bebras challenge.

Furthermore, developing a longitudinal approach enables us to establish relationships between teacher perceptions and Bebras challenge outcomes, shedding light on how these perceptions influence students' performance in such assessments over time. Additionally, we aim to investigate potential disparities in teacher perceptions between urban and rural schools, as well as across different sociocultural quintiles, and evaluate their repercussions on student performance in the Bebras challenge. Identifying these disparities will inform the design of targeted interventions aimed at addressing gaps in STEM education and fostering equitable opportunities for all students.

Moreover, this first descriptive analysis leaves many questions for research on girls' levels of self-efficacy in STEM fields, with a particular focus on how social stereotypes and cultural norms influence their confidence and motivation. The relationship between the monitoring team's observations of CT classes and teachers' perceptions of active participation and performance in drinking can be further explored. For this, longitudinal studies tracking girls' self-efficacy over time could provide valuable information on the effectiveness of interventions aimed at increasing their confidence in STEM subjects.

To end with, to overcome the difficulty of not having a standardized test to measure CT, we are working on the validation of more than 200 items to assess the level of acquisition of computational thinking competence and all its skills. By the end of 2024, the first national assessment of sixth graders is expected to be carried out with an instrument based on the Bebras items, translated and adapted to the Uruguayan context, from which it will be possible to obtain conclusions that are more in line with reality and work to improve the gender gap in computational thinking in Uruguay.

Notes

1. ceibal.edu.uy.
2. https://www.powerschool.com.
3. https://www.bebras.org/.
4. https://www.anep.edu.uy/monitor/servlet/definiciones.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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