Journal on Interactive Systems, 2026, 17:1
ISSN: 2763-7719 • doi: 10.5753/jis.2026.7287

Research Paper

Organization and Impacts of the CF-OBI: Results of the Three Editions

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Abstract. This paper presents the organizational methodology and longitudinal results of the Girls' Competition of the Brazilian Olympiad in Informatics (CF-OBI) across its first three editions (2023, 2024, and 2025). The results demonstrate a significant increase in female participation across all levels, particularly in the Junior, Level 1, and Level 2 categories of the Programming track. Notably, both the number of registered students and active participants grew substantially during this period, with the Junior level showing the most pronounced expansion. Data analysis reveals distinct patterns in geographic concentration, institutional engagement, and territorial reach, which are directly relevant to discussions on scalability and inclusiveness in technology-mediated educational initiatives. The findings suggest that the CF-OBI provides a supportive and strategically pivotal learning environment, suggesting its potential as an entry point for encouraging female inclusion in computing.

Keywords: Female Participation, Competitive Programming, Brazilian Olympiad in Informatics, STEM Education

Edited by: Claudia Cappelli | **Received:** 21 December 2025 • **Accepted:** 13 July 2026 • **Published:** 25 July 2026

1 Introduction

The Brazilian National Common Curricular Base (*Base Nacional Comum Curricular* – BNCC) provides a unified framework for K-12 education across Brazil [Brasil, 2017]. It aims to foster creative and critical individuals capable of solving complex problems. While the BNCC establishes minimum competencies, it does not strictly prescribe school curricula. Instead, it mandates that education systems and schools contextualize these guidelines, adapting them to regional and cultural specificities. These adaptations are formalized through state and municipal curricula, which detail content, methodologies, and implementation strategies.

In 2022, the Brazilian Ministry of Education (MEC) formally integrated Computing into K-12 education through a specific normative supplement [Conselho Nacional de Educação, 2022]. This supplement anchors Computing within the "Digital Culture" competency, emphasizing the ethical and creative use of technology. Notably, rather than focusing solely on technical content, this approach aligns with the BNCC's premise of Computational Thinking as a transversal skill. The goal is to develop critical citizens prepared to use technology responsibly throughout their education.

Nevertheless, curriculum implementation alone does not ensure equity in access to and retention within technological fields. Data from the Anísio Teixeira National Institute of Educational Studies and Research (INEP) spanning 2014 to 2019 regarding female representation in higher education Computing courses in Brazil were analyzed by Santos *et al.* [2021]. The study revealed that the proportion of female students fluctuated between 13.8% and 15.2%, evidencing gender inequality in both enrollment figures and graduation rates. Saraiva *et al.* [2023] indicate that, despite slight growth in the Technology field as a whole, the percentage of female graduates in Computing specifically remains stagnant at 13.8%.

To bridge this gap and meet the BNCC's demand for active learning methodologies, programming competitions have emerged as an effective educational paradigm. These contests challenge participants to solve Computer Science problems under strict time constraints, fostering essential skills such as algorithm design, logical reasoning, and data structures.

More specifically, programming competitions require students to write code that executes correctly within a limited timeframe. They involve core concepts, such as logic, mathematics, and data structures, essential for implementing efficient solutions. Furthermore, they demand the analysis of time and space complexity and proficiency in programming languages. Beyond technical knowledge, these events cultivate the ability to decompose complex problems, apply optimization techniques, and ensure precision in computational solutions [Lertbanjongam *et al.*, 2022].

Consequently, these competitions have become a new paradigm in computing education, potentially filling gaps in traditional training and developing skills crucial for professional success. Studies indicate that participation significantly enhances problem-solving abilities among computing students [Raman *et al.*, 2018; Moura *et al.*, 2019; Sousa *et al.*, 2021].

In addition to technical proficiency, programming competitions foster an environment conducive to talent development, encouraging academic excellence [Vitorino *et al.*, 2018; Solórzano *et al.*, 2019]. Their collaborative and challenging nature also promotes teamwork and effective communication, better preparing students for real-world problem-solving contexts [Bloomfield and Sotomayor, 2016; Theodoro *et al.*, 2024].

A historical analysis of the Brazilian National Programming Contest (Maratona Nacional de Programação) reveals a substantial increase in female participation, reaching 15% in the 2024 finals. This growth highlights the importance of initiatives fostering gender diversity in technology [Ramos *et al.*, 2025], driven by incentive actions and reserved spots for affirmative action created to support the inclusion of girls [Irion *et al.*, 2024].

Within this context, the Girls' Competition of the Brazilian Olympiad in Informatics (CF-OBI), the official Portuguese name of the event is *Competição Feminina da OBI*, program established in 2023 as an extension of the Brazilian Olympiad in Informatics (OBI) represents a direct response to the challenge of inclusion [Olimpíada Brasileira de Informática, 2024]. The initiative aims to promote the participation of young women and non-binary individuals through three difficulty levels: Junior, Level 1, and Level 2. Unlike traditional competitions, the CF-OBI adopts a methodology that integrates the four pillars of Computational Thinking (decomposition, pattern recognition, abstraction, and algorithms) with storytelling. This narrative-based approach contextualizes abstract problems, requiring participants to exercise abstraction to model efficient computational solutions.

This paper presents a longitudinal descriptive analysis that documents participation trends, organizational dynamics, and geographic patterns across three consecutive editions, providing an empirical foundation for future intervention and impact studies. Distinguishing itself from isolated experience reports, this study employs a rigorous quantitative methodology, utilizing statistical hypothesis testing, including Chi-Square and Fisher's Exact tests, to validate the significance of participation growth. Results show a substantial increase in registrations, particularly at the Junior level in 2025, which rose from 694 in 2023 to 2,953. Concurrently, the analysis identifies critical challenges regarding the conversion rate from registration to active participation, as well as the geographic concentration of talent, predominantly in the state of São Paulo and the Northeast region.

Beyond detailing the organizational methodology, the infrastructure based on the Contest Management System (CMS), and the challenge design process, this paper discusses the pedagogical and organizational implications of the results. The analysis aims not only to document the initiative's quantitative success but also to provide insights into scalability and inclusion that may inform public policies and future affirmative actions. In doing so, it aligns with the BNCC's broader objectives of fostering critical thinking, citizenship, and equitable access to computing education.

This paper is an extended and substantially revised version of a conference paper previously published in the proceedings of the XIX Women in Information Technology Workshop [Santos *et al.*, 2025]. While the conference paper reported only on the 2023 and 2024 editions of the CF-OBI, this manuscript extends the longitudinal scope to include the 2025 edition, enabling trend analysis across three consecutive years. In addition, this version introduces new inferential statistical analyses, specifically paired t-tests and Fisher's Exact Tests, that were absent from the original work. A new section (Section 7.1) provides a granular analysis of participation patterns by Brazilian state and educational institution, offering insights into geographic and institutional engagement dynamics that were not addressed in the conference paper. Furthermore, the entire text has been rewritten in English and restructured to meet the standards of a full research article, with expanded pedagogical discussion of the implications of the findings.

The remainder of this paper is organized as follows. Section 2 discusses related work on gender inequality in informatics olympiads. Section 3 describes the CF-OBI, highlighting its objectives, structure, and pedagogical connections. Section 4 details the methodological approach, including research questions and data analysis procedures. Section 5 outlines the competition's organization, from registration to result dissemination. Section 6 presents findings from the 2023–2025 editions. Section 7 discusses these findings, examining participation growth and statistical significance. Finally, Section 8 summarizes the conclusions and emphasizes the initiative's relevance.

1.1 Ethical issues

This study was conducted in strict adherence to ethical principles regarding data privacy and participant protection. Given the retrospective and quantitative nature of the analysis, which relied solely on anonymized administrative data, formal approval from an Institutional Review Board (IRB) was not required for this phase. Nevertheless, rigorous measures were implemented to ensure confidentiality: no Personally Identifiable Information (PII), such as names, ID numbers, or contact details, was processed or stored for the purposes of this research.

All data were obtained from the CF-OBI organizing committee, their use was strictly limited to the purposes of this study. To mitigate the risk of indirect re-identification in geographic and institutional analyses, participation and performance data are reported exclusively at an aggregate level (e.g., total registrations and medal counts per institution or state). No combination of attributes capable of enabling the identification of individual participants is disclosed in any table or figure.

The gender category was operationalized based on participants' voluntary self-identification at the time of competition registration, consistent with the options available in the official CF-OBI registration form.

In reporting regional disparities in participation and performance, care was taken to frame observed differences in terms of structural conditions, infrastructure access, and institutional capacity in order to avoid stigmatization of states or educational contexts with lower engagement levels.

2 Related Work

Gender Disparities in Computing Education and STEM Competitions

The under-representation of women in computing education and STEM careers is a well-documented structural challenge in Brazil. Santos *et al.* [2021] analyzed data from the INEP spanning 2014 to 2019 and found that the proportion of female students in higher education Computing courses fluctuated between 13.8% and 15.2%, evidencing persistent gender inequality in both enrollment and graduation rates. Saraiva *et al.* [2023] corroborate this finding, indicating that despite slight growth in the Technology field as a whole, the percentage of female graduates in Computing specifically remains stagnant at 13.8%.

These patterns are consistent with what Blickenstaff [2005] describes as the leaky pipeline model, which characterizes the progressive loss of women at each stage of the educational and career pathway in STEM fields. Applied to the Brazilian context, this lens helps interpret not only the under-representation observed in higher education but also the registration-to-participation conversion gaps documented in programming competitions at the secondary level.

Within programming competitions specifically, Silva *et al.* [2025] investigated gender inequality in the OBI over the past decade, conducting a quantitative analysis of participation and medal distribution across the Junior, Level 1, and Level 2 Programming tracks. Their results reveal a persistent male dominance in both participation numbers and award distribution. Although recent inclusion-oriented initiatives have led to sporadic increases in female participation, the gender gap remains significant, suggesting the persistence of structural and sociocultural barriers. The recent growth in female participation in the Brazilian National Programming Contest, reaching 15% in the 2024 finals, is attributed in part to affirmative reserved spots and institutional incentives [Ramos *et al.*, 2025; Irion *et al.*, 2024].

Miguel *et al.* [2025] documented an experience report on encouraging girls to participate in the OBI, illustrating the potential of school-level initiative approaches that complement national-level competitions. Similarly, Almeida and Gheyi [2024] analyzed factors influencing female participation in programming competitions, identifying motivational, structural, and pedagogical dimensions that align with the patterns observed in the CF-OBI data.

Socio-cultural and Structural Barriers and Affirmative Strategies

Beyond aggregate statistics, qualitative research has shed light on the mechanisms that deter female engagement in computing-related competitive environments. Paganini and Gama [2020] conducted a qualitative case study of Hack Grrrl, a hackathon aimed primarily at women, interviewing 26 participants to identify barriers and motivators. Their findings highlight that low self-esteem and environments marked by toxic masculinity act as significant deterrents, while learning opportunities, networking, and practical experience were identified as primary drivers for engagement. The positive impact of safe, female-led environments on self-confidence and sense of belonging documented in their study is directly relevant to the CF-OBI's inclusive design principles.

These findings are theoretically grounded in Bandura's self-efficacy theory [Bandura, 1997], which posits that individuals' beliefs in their own capabilities are a key determinant of participation and persistence in challenging domains. In the context of computing competitions, low self-efficacy among female students, often shaped by gender stereotypes and lack of role models, may contribute to both the decision not to participate and the decision to withdraw after registration. Eccles' expectancy-value model [Eccles, 2009] further frames this dynamic: students are more likely to engage in activities they perceive as valuable and in which they expect to succeed, making the welcoming and narrative-based design of the CF-OBI a potentially important factor in reducing these barriers.

Affirmative strategies targeting female participation in Brazilian computing competitions have been documented by Pessoa *et al.* [2017], Bastos *et al.* [2017], and Lima *et al.* [2021], who report positive outcomes from training groups, mentoring initiatives, and female-focused competitive spaces. Vitorino *et al.* [2018] examined the profiles of medalists from the Paraíba Informatics Olympiad and found that preparation strategies vary by expertise level and that many high-achieving participants had prior experience in other scientific competitions, underscoring the role of early and sustained engagement in building competitive competencies.

Competition-based Educational Strategies and Scalability

Programming competitions have emerged as an effective educational paradigm for developing computational thinking and problem-solving skills [Bloomfield and Sotomayor, 2016; Raman *et al.*, 2018; Moura *et al.*, 2019; Sousa *et al.*, 2021; Lertbanjongam *et al.*, 2022]. These events foster algorithm design, logical reasoning, and data structures while cultivating teamwork and communication skills [Bloomfield and Sotomayor, 2016; Theodoro *et al.*, 2024]. Solórzano *et al.* [2019] and Vitorino *et al.* [2018] further highlight the role of competitions in talent identification and academic excellence, reinforcing their value as scalable tools for engaging students beyond formal curricula.

From a scalability perspective, the adoption of open-source contest management platforms such as CMS [Maggiolo and Mascellani, 2012] enables national-level competitions to be administered with consistent technical standards across heterogeneous infrastructural contexts, as is the case in the CF-OBI.

Research Gap: National Longitudinal Studies

Despite the growing body of literature on gender inclusion in computing competitions, studies that provide longitudinal, multi-edition, quantitative analyzes of national-level initiatives remain scarce. Most existing research focuses on single events, qualitative experiences, or isolated editions [Miguel *et al.*, 2025; Lima *et al.*, 2021; Pessoa *et al.*, 2017], which limits the ability to assess whether the observed growth trends are sustained over time. Moreover, few studies simultaneously analyze participation patterns, geographic concentration, and institutional engagement dynamics across consecutive editions of a competition.

This paper addresses this gap by providing a longitudinal descriptive analysis of three consecutive editions of the CF-OBI (2023–2025), employing inferential statistics to validate observed trends and introducing a granular examination of geographic and institutional concentration patterns at the national level.

3 Girls' Competition of the Brazilian Olympiad in Informatics

The CF-OBI was established in 2023 as an extension of the OBI. It is a programming competition designed for female and non-binary students at the elementary and high school levels. The literature indicates that such competitions serve as effective tools for attracting and retaining women in the computing field [Lima *et al.*, 2021; Bastos *et al.*, 2017; Pessoa *et al.*, 2017].

The CF-OBI distinguishes itself from other initiatives through its specific focus on programming for basic education and its commitment to diverse gender identities. The competition is structured into three distinct levels, namely Junior Programming, Level 1, and Level 2, to accommodate students with varying degrees of expertise. Beyond certificates and medals, high-performing students are invited to the OBI Olympic Week. This opportunity grants eligibility to compete for spots in international contests, thereby significantly boosting participant engagement and motivation [Olimpíada Brasileira de Informática, 2024].

The competition is organized around the following pillars:

- **Focus on Programming**: the event is dedicated exclusively to programming and offers three difficulty levels to engage competitors of different ages and experiences.
- **Inclusive Environment**: the organization ensures a welcoming and safe space for all participants.
- **Recognition and Pathways**: participants receive certificates and top-ranked competitors are awarded medals. Furthermore, the top two students in each level are invited to the OBI Olympic Week, where they can access advanced courses and may qualify for the Brazilian team in international competitions.
- **Skill Enhancement**: the initiative strengthens learning through courses and activities designed to improve technical proficiency in the field.

Similar to the OBI, the CF-OBI employs challenges that encompass algorithm design, logic, mathematics, and data structures. These tasks are directly linked to the development of computational thinking [Santos *et al.*, 2024], which is defined as a fundamental skill set for solving problems in a systematic and efficient manner.

According to Wing, computational thinking relies on four main pillars: decomposition, pattern recognition, abstraction, and algorithm design. Consequently, the CF-OBI challenges are carefully structured to require the application of these pillars, as detailed in Table 1.

4 Method

This study adopted a longitudinal case study design, analyzing participation, performance, and organizational data from the first three editions of the CF-OBI (2023–2025). This approach enables the understanding of changes over time and the identification of engagement patterns in inclusion initiatives.

4.1 Data Collection

This study utilized a combination of publicly available records and institutional datasets furnished by the OBI organizing committee. The analysis comprised the following data points:

- the number of registered participants per level and year;
- the number of active participants;
- the distribution of medals by state;
- the recurrence of medalists across multiple editions;
- records of submissions evaluated by the Contest Management System (CMS).

While records related to medalists are publicly accessible on the official Olympiad website, the organizing committee provided the remaining data for research purposes, specifically the submission logs from the CMS. All datasets were anonymized in strict accordance with ethical and privacy guidelines for educational research [Commission, 2021].

4.2 Data Analysis

The analytical framework was organized into three stages:

- **Descriptive Analysis**: focused on general statistics regarding the growth of registrations, participation rates, and medal distribution.
- **Inferential Analysis**: involved the application of Chi-Square and Fisher's Exact tests, adhering to current recommendations for proportion comparisons in educational studies with small or unbalanced samples [Abdulrazak *et al.*, 2020; Leal *et al.*, 2005].
- **Recurrence Analysis**: identified competitors awarded in multiple editions to characterize retention and academic progression.

The paired t-test was selected for the longitudinal comparison of participation counts because measurements are naturally paired by competition level across editions. Each level (PJ, P1, P2) constitutes an independent stratum, and the test evaluates whether the mean number of active participants differs significantly across the three years within each stratum. Given that only three observations per level are available, the small-sample properties of the t-test are appropriate for this design [Field, 2018].

Fisher's Exact Test was applied for pairwise year comparisons of participation proportions, defined as active participants relative to registered participants, because cell frequencies in several comparisons fell below the threshold recommended for the asymptotic Chi-Square approximation. Fisher's Exact Test computes an exact probability without relying on large-sample assumptions, making it particularly suitable for small or unbalanced contingency tables [Abdulrazak *et al.*, 2020; Leal *et al.*, 2005].

Importantly, both tests are applied within a descriptive and longitudinal research design: they establish the statistical

Table 1. Correlation with Computational Thinking. Source: [Santos *et al.*, 2025]

COMPUTATIONAL THINKING AXIS	ACTIVITIES IN CF-OBI
Decomposition	Participants need to break down proposed problems into subproblems, such as identifying inputs, outputs, and intermediate steps.
Pattern Recognition	During resolution, participants recognize patterns in data structures or algorithms that can be applied in different contexts.
Abstraction	Participants abstract essential data and information to model the problem and create an efficient solution.
Algorithm Design	The creation of algorithms is the main focus of the competition, requiring participants to design, implement, and test their solutions.

significance of observed temporal trends but do not support causal inference. The unit of analysis for the t-tests is the level–year combination; for Fisher's Exact Test, it is the participation proportion within each level–year pair.

All analyses were performed using the Python programming language (specifically the *pandas* and *scipy* libraries), ensuring full reproducibility in alignment with open science practices.

5 Organization and Planning of the CF-OBI

The organization of the CF-OBI follows a structured methodology, established by a timeline that coordinates all event phases, from dissemination to exam administration and result publication. Figure 1 outlines this workflow, and the subsequent subsections provide a detailed description of each stage.

5.1 Planning

The planning phase encompassed the definition of strategic objectives, the establishment of a timeline, and the formation of a support committee composed exclusively of female computing professionals.

5.2 Registration

Registration must be facilitated by a school teacher or staff member, designated as the Local OBI Coordinator, via the official OBI website [Olimpíada Brasileira de Informática, 2024]. Participation is entirely free of charge. Furthermore, students may enroll in any CF-OBI level for which they are eligible, independent of their concurrent registration in the standard OBI track.

Students from schools without adequate infrastructure to host the exam may participate at another registered host school, provided that the Local OBI Coordinators of both institutions have agreed upon this arrangement. In all cases, participants are represented by their enrolled institution in the competition results.

5.3 Creation of the Competition Environment

The competition infrastructure relies on the Contest Management System (CMS), an open-source platform specifically designed for programming contests following

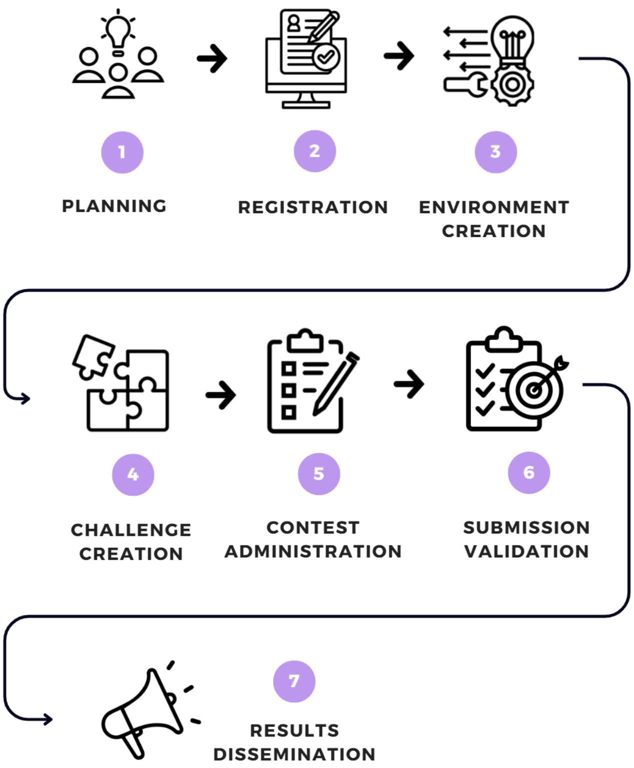

Figure 1. Workflow of activities carried out for the competition. Source: [Santos *et al.*, 2025]

the International Olympiad in Informatics (IOI) format[1]. Prioritizing security and adaptability, the system employs a modular architecture that supports service replication for scalability. To prevent fraud, the execution of untrusted code is isolated within secure sandboxes. Additionally, CMS utilizes an immutable file-based data model backed by a PostgreSQL database to ensure data integrity and deduplication [Maggiolo and Mascellani, 2012]. Figure 2 illustrates the system architecture.

For the creation of the CF-OBI environment, CMS is used as a containerization tool, and the following steps were carried out in this process:

- Preparation: configuration of the online platform for registration and exam administration.

[1] https://ioinformatics.org/

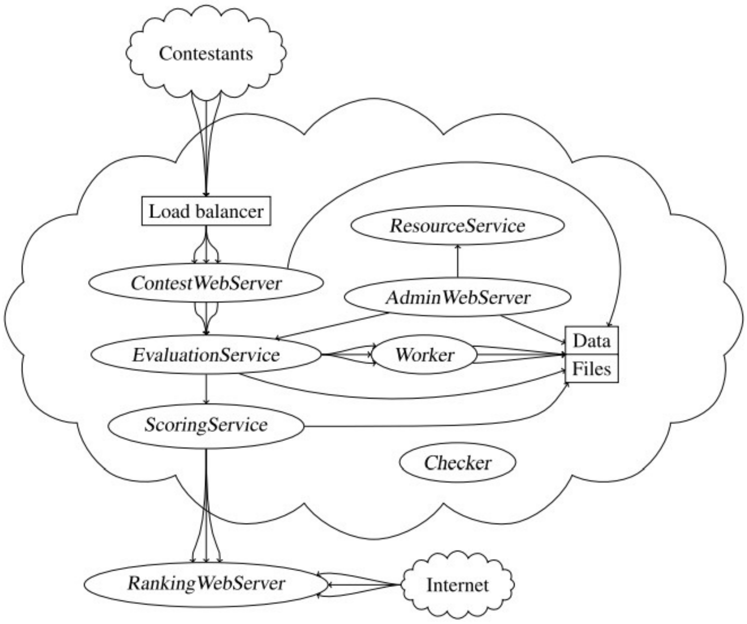

Figure 2. Architecture of the Contest Management System (CMS). Source: Maggiolo and Mascellani [2012].

- Problem preparation: adaptation of challenges to the platform format.
- Testing: verification of platform functionality and problem correctness.

5.4 Challenge Creation

The process of creating challenges is rigorous and designed to ensure that participants feel engaged without encountering insurmountable difficulty. The entire organizing team participates in this phase by proposing themes and algorithms for the competition problems.

Notably, consistent with the OBI methodology, the challenges always incorporate storytelling. Rather than being presented in a purely mathematical or abstract manner, the problems are contextualized through narratives and situational scenarios. This narrative approach is intentional and pedagogical because it requires participants to exercise the abstraction pillar of Computational Thinking. They must identify essential data within the story to model the problem and formulate an efficient solution.

The syllabus is organized by level and is available on the OBI website. The main thematic areas include:

1. Mathematical Foundations: Arithmetic and Geometry, Logic, Discrete Mathematics, and Graphs;
2. Computing Foundations: Basic Informatics and Programming (syntax, semantics, variables, and structures);
3. Algorithms and Data Structures;
4. Algorithm Analysis: Complexity, Algorithmic Strategies, Data Structures, Sorting and Searching Algorithms, Mathematical Algorithms, Graph and Tree Algorithms, and Geometry Algorithms.

The team holds meetings to calibrate the exam, aiming to comprehensively balance difficulty and address all skill levels. Problems are structured according to the competition categories (Junior, Level 1, and Level 2) and aligned with their corresponding syllabi. The challenges are designed to stimulate logical reasoning and creativity, which are essential skills for developing complex competencies. Furthermore, pairwise testing allowed for a thorough review to ensure the quality and appropriateness of the proposed problems. Overall, the activities of this stage are summarized in Figure 3.

5.5 Contest Administration

The exams are administered on a single day and take place in person at designated host schools. The assessment window spans from 08:00 to 18:00 (Brasília Standard Time) to accommodate participants across different time zones and varying school schedules. Each competitor may begin the exam at any point within this window and has a maximum of three hours from the moment they initiate the exam to complete all tasks, regardless of when within the window they begin.

On the scheduled date, host institutions are required to provide individual computers equipped with Internet access to facilitate system login. Solutions are submitted via the OBI website and may be implemented in C, C++, Python, Java, or JavaScript. Figure 4 depicts the system interface.

For each challenge, a description, expected inputs, and outputs are provided, and competitors must upload the file containing their solution to the website. CMS, acting as an online judge, evaluates the submitted code and automatically presents the obtained score. During the exam period, competitors may attempt solutions an unlimited number of times without penalties for incorrect submissions.

5.6 Submission Validation

During the exam, participants' submissions are automatically evaluated by CMS by comparing expected outputs with those generated by competitors' solutions. Each challenge contains subsets of test cases with different scoring weights; these subsets are referred to as *subtasks* and aim to assess different implementations capable of solving the same problem.

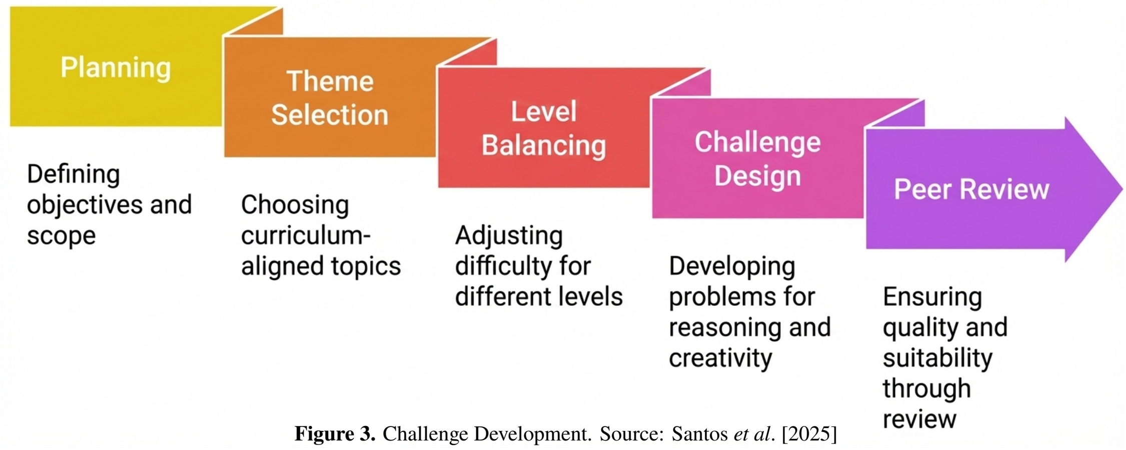

Figure 3. Challenge Development. Source: Santos *et al*. [2025]

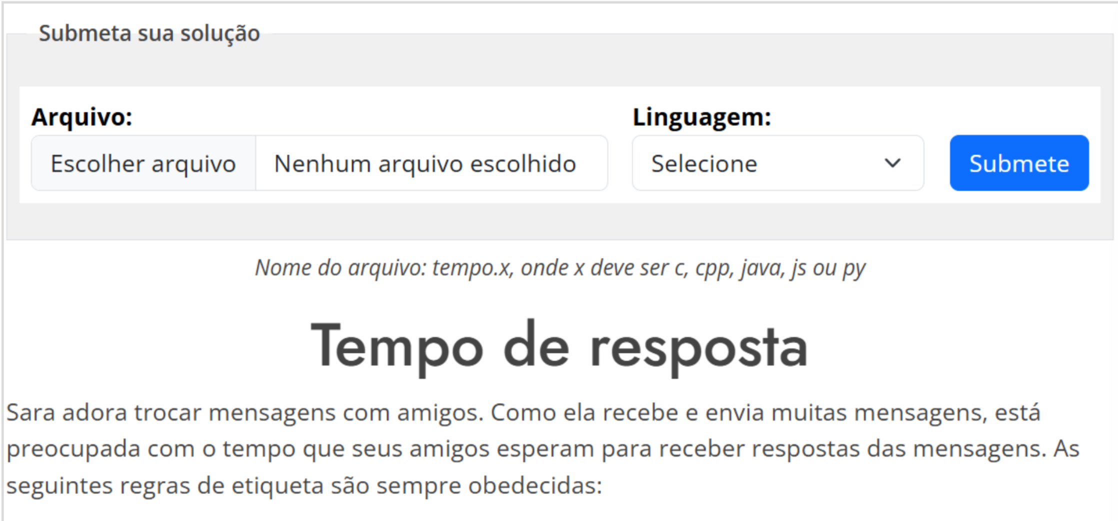

Figure 4. OBI system submission interface.

Note: The interface is presented in its original Portuguese, as the platform operates exclusively in that language for Brazilian participants. Key elements visible: file upload field (Arquivo), programming language selector (Linguagem), and submission button (Submete).

Figure 5 illustrates a representative feedback screen returned by the CMS after a partially correct submission. The summary displays the total score (in this case, 10 out of 100), the programming language used, and the time and memory constraints alongside the actual resources consumed. At the subtask level, each test case receives an individual verdict (Correct or Incorrect) accompanied by execution time and memory usage. In the example shown, the participant's solution passed all five test cases of Subtask 2 (10/10) but failed the first test case of Subtask 1, resulting in a score of 0/10 for that subtask. This partial-scoring model enables participants to identify which aspects of the problem their solution handles correctly, thereby supporting iterative refinement without penalizing unsuccessful attempts. A formal usability evaluation of the feedback system from the participant's perspective is identified as a direction for future research.

After the exam, the responsible team carries out a rigorous and systematic submission review process. Initially, an automatic code similarity analysis is performed to identify potential indications of full or partial copying. When solutions with a high degree of equivalence are detected, comparisons consider not only content but also coding style and the educational institution of origin, examining elements such as code structure, employed logic, internal organization, and implementation choices.

Additionally, manual verification is conducted in cases that raise concerns, particularly when there are indications of the use of Artificial Intelligence (AI)-based code generation tools. This stage is performed independently by pairs of reviewers, ensuring greater robustness in the validation process. In this procedure, all submissions from each participant are jointly analyzed to verify logical coherence, consistency of writing patterns, and the maintenance of an individual coding style across different solutions.

This evaluation protocol aims to ensure process integrity and guarantee that assigned performance accurately reflects each participant's individual work. In cases of plagiarism or confirmed AI-generated solutions, the competitor is disqualified.

5.7 Result Dissemination

Upon the conclusion of the process, the results are disseminated via the official OBI website. Top-performing

Resumo da correção

Pontuação	10 / 100
Linguagem	Python 3 / CPython
Limite de tempo permitido	0,1 s
Limite de memória permitido	64.0 MB
Máximo tempo usado	0,028 s
Máxima memória usada	4.17 MB

Detalhes da correção

Execução dos testes

Subtarefa 1 — 0 / 10

#	Resultado	Detalhes	Tempo de execução	Memória usada
1	Incorreto	A saída está errada	0,02 seg	3.81 MB
2	Correto	A saída está correta	0,021 seg	3.82 MB
3	Correto	A saída está correta	0,022 seg	3.91 MB
4	Correto	A saída está correta	0,021 seg	3.92 MB
5	Correto	A saída está correta	0,02 seg	3.81 MB

Subtarefa 2 — 10 / 10

#	Resultado	Detalhes	Tempo de execução	Memória usada
1	Correto	A saída está correta	0,026 seg	3.82 MB
2	Correto	A saída está correta	0,02 seg	3.81 MB

Figure 5. OBI system feedback interface.

Note: The interface is displayed in its original Portuguese, as the platform operates exclusively in that language. Key terms: *Pontuação* (Score), *Subtarefa* (Subtask), *Correto/Incorreto* (Correct/Incorrect), *Tempo de execução* (Execution time), *Memória usada* (Memory used).

participants are awarded certificates and medals. Furthermore, they gain opportunities to participate in prestigious international informatics events.

Notably, the CF-OBI serves as the selection mechanism for the European Girls' Olympiad in Informatics (EGOI), designating the four highest-ranked competitors to represent the country. EGOI is an international contest for individual participants from Europe and invited nations, which also features social and cultural programs. Brazil has achieved significant success in this event, securing a total of 16 medals in the five years since the Olympiad's inception.

As the premier international competitive programming contest dedicated to young women, EGOI aims to provide a platform for participants to deepen their interest in Computer Science and encourages them to compete at an international level. Additionally, the event seeks to discover talent, create female role models, and promote cultural exchange. It fosters friendly relations among countries, competitors, educators, and computer scientists [EGOI, 2025].

6 Results

This section presents the results of the CF-OBI across its first three editions (2023–2025), organized by year and competition level to enable the observation of longitudinal trends in registrations, active participation, award distribution, and institutional engagement. The competition levels follow the official CF-OBI designations and are abbreviated throughout as: PJ (Junior Programming / *Programação Júnior*), P1 (Level 1 Programming / *Programação Nível 1*), and P2 (Level 2 Programming / *Programação Nível 2*).

The data are categorized by year and level to facilitate the observation of growth and retention trends as well as regional differences. In addition to descriptive statistics, inferential tests are employed to assess the statistical significance of the observed variations, offering a quantitative basis for evaluating the initiative's growth over time.

In all three editions, planning and organizational activities spanned from April to September, coordinated by a committee composed predominantly of women from the computing field to foster a representative and inclusive environment. The top-ranked participants at each level were awarded gold, silver, and bronze medals in addition to participation certificates. Top-scoring competitors in P2 were selected to participate in the International Competitions Selection Process during the OBI Olympic Week.

6.1 Data from 2023

The CF-OBI was launched in 2023, with the first edition taking place on September 1st. The event generated substantial interest. Registration numbers were 694 for the Junior Level, 672 for Level 1, and 1260 for Level 2, which had the highest demand. Actual participation figures were 91 for the Junior Level, 158 for Level 1, and 162 for Level 2, as shown in Table 2.

Table 2. Participation Data - 2023

Level	Registered	Participants	% Participation
PJ	694	91	13,1%
P1	672	158	23,5%
P2	1260	162	12,9%

In this edition, the competition featured four distinct challenges for each level. A total of 36 students received prizes, with 12 medals allocated to each level.

6.2 Data from 2024

The 2024 edition was held on September 13th and was characterized by accelerated growth and consolidation of the CF-OBI. Level 2 exhibited the most notable expansion: registrations rose to 1,997 (a 58.4% increase) while active participation more than doubled to 333 competitors (an increase of 105.5%), as detailed in Table 3.

Table 3. Participation Data - 2024

Level	Registered	Participants	% Participation
PJ	925	102	11,0%
P1	953	197	20,7%
P2	1997	333	16,7%

In this edition, the competition featured four distinct challenges for PJ and P1, and five for P2. A total of 43 students received awards: 21 medals in PJ, 12 in P1, and 10 in P2. The organizing committee comprised 21 members and held biweekly 30-minute meetings to discuss challenge design strategies, exam logistics, and result validation.

6.3 Data from 2025

The 2025 edition took place on September 12 and focused on sustaining large-scale growth and refining the methodology. Registration numbers reached 2,953 for PJ, 1,268 for P1, and 2,502 for P2. Active participation also reached a record high for the series, with 110 competitors in PJ, 244 in P1, and 476 in P2, as summarized in Table 4.

In this edition, the competition presented four distinct challenges for PJ and P1, and five challenges for P2. Collectively, 44 students were awarded. Specifically, 14 medals were distributed to top finishers in PJ, 12 in P1, and 18 in P2.

Table 4. Participation Data - 2025

Level	Registered	Participants	% Participation
PJ	2953	110	3,73%
P1	1268	244	19,24%
P2	2502	476	19,02%

The organizing committee expanded to 25 members and adopted a revised meeting structure of approximately three-week intervals with one-hour sessions. Once problems were developed, a separate dedicated team handled testing and validation, reflecting a more mature organizational model compared to previous editions.

6.4 Medalists and Performance Trends (2023–2025)

The analysis of award outcomes for the CF-OBI editions from 2023 to 2025 revealed consistent performance patterns and a notable concentration of high-achieving participants. Figure 6 illustrates the distribution of awards across the analyzed years.

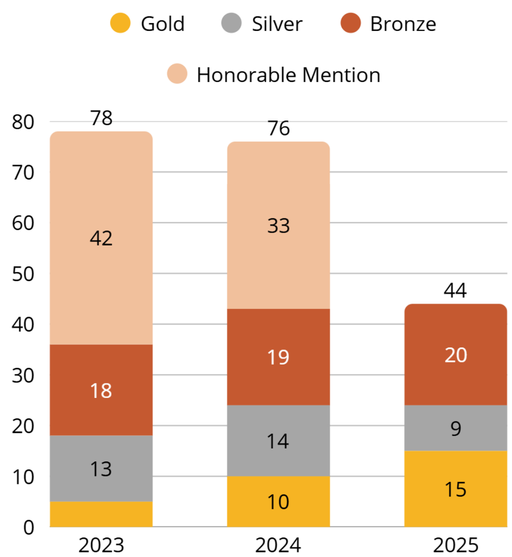

Figure 6. Medal distribution by year

The analysis of medal distribution by state revealed a marked geographic concentration of talent. The state of São Paulo (SP) exhibited overwhelming dominance in the competition by securing 116 medals, as illustrated in Figure 7. This figure is more than five times greater than the total obtained by the second-ranked state.

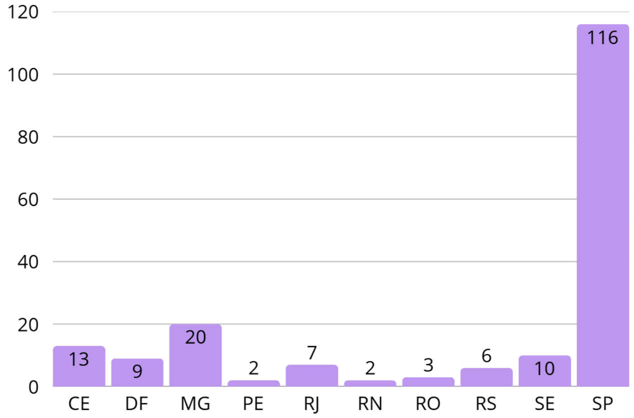

Figure 7. Top 10 States in Number of Medals

Data from the 2023–2025 editions reveal a recurring pattern of success among competitors. In total, 31 students received awards in multiple CF-OBI editions. More specifically, 20 students earned medals in two separate years, and 11 achieved this distinction in all three editions. This consistency underscores the initiative's capacity to retain high-performing talent in the programming field.

7 Analysis of Results and Discussion

The analysis of the results comprehensively examines the evolution of registered students and active participants in the CF-OBI across the Junior, Level 1, and Level 2 categories from 2023 to 2025. Figures 8, 9, and 10 visually summarize this evolution. They facilitate the observation of both absolute growth and the relative distribution of participation across categories and years.

Overall, a substantial increase in registrations is evident across all levels. The Junior level exhibits a particularly pronounced rise between 2024 and 2025. As shown in Figure 8, registrations in this category surged from 694 in 2023 to 2,953 in 2025. This growth highlights the success of outreach actions aimed at expanding the competition's reach among younger students. A similar though less dramatic trend appears in the Level 1 and Level 2 categories, which also demonstrate steady growth throughout the analyzed period.

However, when examining the number of active participants, it becomes evident that this growth is not proportional to the increase in registrations. As shown in Figure 8, the Junior level presents only a modest rise in the number of attendees from 91 in 2023 to 110 in 2025. This stands in sharp contrast to the substantial surge in registrations. Conversely, Level 1 and particularly Level 2 exhibit a more consistent increase in participation numbers. Notably, Level 2 accounts for the largest share of actual turnout across all analyzed years as evidenced in Figure 9.

This discrepancy between registrations and active participation becomes more apparent when analyzing the distribution of participants by category and year (Figure 10). Although the Junior level attracts a large volume of registered students, its relative contribution to the total number of participants remains limited. In contrast, Level 2 demonstrates a proportionally higher participation rate, especially from 2024 onward. These findings suggest that factors related to age group, academic maturity,

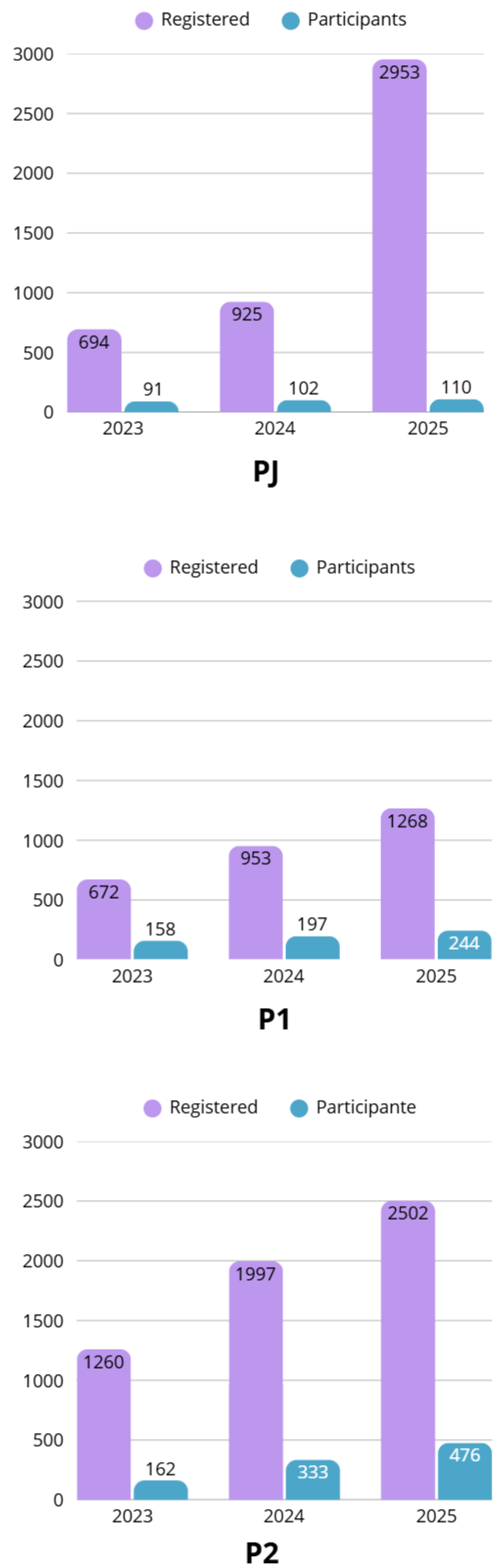

Figure 8. Registered vs. Participants

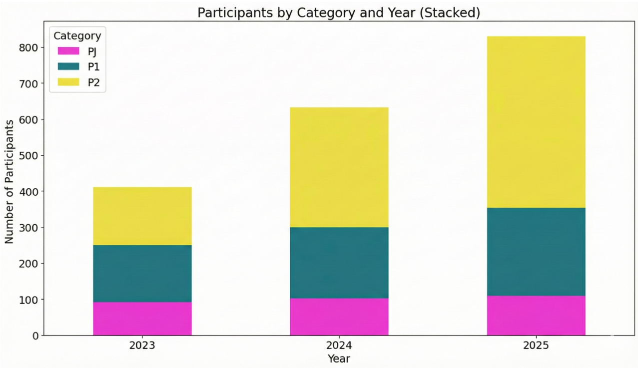

Figure 9. Participants. vs Year

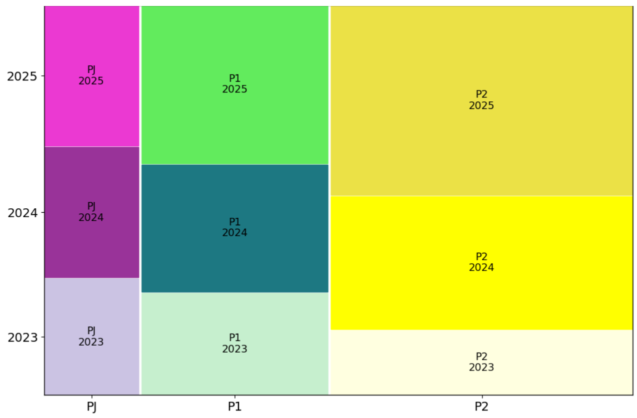

Figure 10. Category vs. Year

and persistence throughout the competitive process may directly influence the conversion of registrations into actual attendance.

An additional pattern worth noting is the consistently lower registration numbers at P1 compared to both the PJ and P2. A plausible explanation lies in the official OBI eligibility rules: students in their first year of secondary education are simultaneously eligible for both P1 and P2 [Olimpíada Brasileira de Informática, 2026]. This overlap creates a strategic incentive for eligible students to register directly at P2, since it is the only level that grants access to the international competition pathway, including the selection process for EGOI and IOI, held during the OBI Olympic Week. Consequently, the lower P1 registration figures likely reflect a deliberate upward migration of participants rather than disengagement or barriers to participation at that level. This interpretation is presented as a hypothesis grounded in the competition's institutional design and is identified as a direction for future investigation through participant surveys.

From a statistical perspective, inferential tests were conducted to assess whether the observed temporal variations are significant. Initially, paired t-tests were applied to compare the number of participants across years by considering each level separately. This test was selected due to the temporal nature of the comparisons and the pairing of observations by category. The results indicate statistically significant differences for Level 1 ($p = 0.035$) and Level 2 ($p = 0.027$), which evidences a consistent increase in participation over the analyzed period. Conversely, the t-test for the Junior level did not reveal a statistically significant difference ($p = 0.184$). This reinforces the interpretation that the growth in registrations did not translate into a proportional increase in active participation.

Table 5. T-tests results

Level	Statistic t	p-value
PJ	1.9963	0.1840
P1	5.1916	0.0352
P2	5.9102	0.0275

Furthermore, pairwise comparisons between years were conducted using Fisher's Exact Test. This method is particularly well-suited for analyzing proportions within small samples [Abdulrazak *et al.*, 2020; Leal *et al.*, 2005]. The results disclose statistically significant differences in comparisons involving the 2025 edition for the Junior and Level 2 categories. Significant differences were also observed between 2023 and 2025 for Level 1. These findings substantiate the visual evidence presented in the figures and imply that recent growth has significantly reshaped participation patterns in the CF-OBI, especially from 2024 onward.

Table 6. Results of Fisher's Exact Test

Comparison	Level	p-value
2023 vs 2024	PJ	0.2151630391
2023 vs 2025	PJ	0.0000000000
2024 vs 2025	PJ	0.0000000000
2023 vs 2024	P1	0.1801298822
2023 vs 2025	P1	0.0294131962
2024 vs 2025	P1	0.4203457130
2023 vs 2024	P2	0.0031004838
2023 vs 2025	P2	0.0000016013
2024 vs 2025	P2	0.0422486316

In conclusion, the results demonstrate that the strategies implemented to expand the reach of the CF-OBI were successful in increasing registration numbers across all levels, with a notable surge in the Junior category. Nonetheless, the combined analysis of empirical data and statistical tests indicates that the central challenge lies in converting these registrations into active participation, particularly at the entry levels. Consequently, these findings underscore the importance of complementary actions. Such measures should include pedagogical support, engagement initiatives, and institutional backing for schools and teachers. The goal must extend beyond merely expanding access to ensuring greater persistence and sustained student involvement throughout the competitive process.

7.1 Analysis of Participation by State and Educational Institution

The analysis of participation data reveals distinct patterns of geographic concentration, institutional engagement, and territorial expansion. These findings are directly relevant to discussions regarding scalability and inclusiveness in interactive and technology-mediated educational initiatives. An examination of the distribution across Brazilian federal units reveals a clear predominance of the Southeast region. This trend is driven primarily by the state of São Paulo. Additionally, there is a strong representation of the Northeast

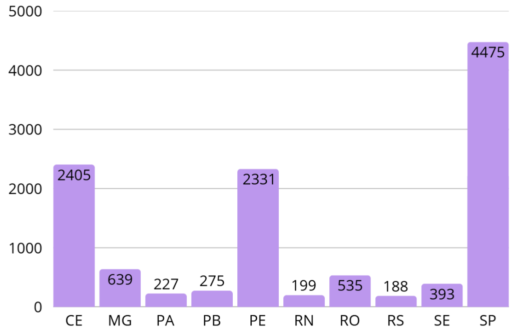

Figure 11. Top 10 states by number of registrations

region, particularly the states of Ceará and Pernambuco. This distribution indicates that participation is shaped not only by demographic factors but also by the presence of consolidated institutional ecosystems capable of sustaining large-scale engagement in computing-related initiatives.

As illustrated in Figure 11, the state of São Paulo leads the national ranking with 4,775 registrations. This figure demonstrates a level of territorial reach substantially higher than that of other states. This volume is nearly twice that of the state ranked second, Ceará, which has 2,405 registrations. Pernambuco follows closely with 2,331 participants. The abrupt decrease observed from the third to the fourth position, represented by Minas Gerais with 639 registrations, indicates a highly asymmetric distribution of participation. Such concentration reflects structural differences in access, dissemination capacity, and institutional readiness to adopt and promote interactive educational systems at scale.

The composition of the top ten states with the highest number of registrations further reveals an expansion of participation beyond the traditional Southeast and South regions. The presence of states from the North and Northeast among the leading participation hubs indicates an ongoing process of territorial diffusion. This suggests that the initiative has begun to reach regions historically less represented in computing competitions of national scope. From the perspective of interactive systems, this diffusion process is a key indicator of system reach and adoption across heterogeneous educational contexts.

At the institutional level, the analysis of the ten schools with the highest number of registrations reveals dynamics that differ from those observed at the state level. Institutional leadership does not necessarily correspond to the overall leadership of the respective state. This indicates that localized organizational strategies play a decisive role in participation outcomes.

A prominent example is Colégio GGE in Recife, which leads the institutional ranking with 2,286 registrations. This single institution accounts for a substantial share of participation within Pernambuco and characterizes a highly centralized engagement model. The GGE's performance in the CF-OBI is consistent with a broader institutional culture of academic competition that is systematically cultivated from the early years of schooling. Since secondary education, the school offers dedicated Olympic Training cohorts, which provide structured preparation for state, national, and international knowledge olympiads across multiple disciplines [Colégio GGE, 2023]. This long-term investment in competitive academic preparation is reflected in the school's consistent record of awards. Whether similar structured preparation programmes exist in other leading CF-OBI institutions, and whether such models could be replicated in public schools with fewer resources, are questions with direct implications for reducing regional participation disparities.

In contrast, the state of São Paulo exhibits a more distributed institutional profile. It occupies five positions in the institutional top ten through a combination of large private educational networks and public state schools located outside the capital. The presence of schools from non-capital cities signals a process of geographic decentralization consistent with the diffusion of innovation beyond early adopter urban centers [Rogers, 2003]. These contrasting models, concentrated in Pernambuco versus distributed in São Paulo, suggest that scalability in interactive educational initiatives may follow different pathways depending on local institutional ecosystems, a finding with direct implications for the design of regional engagement strategies.

Ceará consolidates its position through an institutional cluster concentrated in the city of Fortaleza, where large educational networks collectively account for a significant share of participation. This configuration suggests the existence of network effects, where concentrated institutional engagement contributes to sustained participation over time. In parallel, the inclusion of institutions from the North region among the most engaged schools reinforces the evidence of geographic expansion and increased national reach.

A longitudinal perspective reveals several relevant trends. First, there is a progressive expansion into non-capital cities with increasing involvement of schools located outside capital cities. This is particularly evident in São Paulo, Ceará, Minas Gerais, Rondônia, and Pará. Second, greater regional diversification becomes evident in 2025 with stronger participation from states that previously exhibited lower engagement levels. Together, these trends indicate a transition from a participation model concentrated in major urban centers toward broader integration of state, federal, and municipal education networks. This signals consolidation at the national level.

Recurring institutional patterns further support this interpretation. Large private educational networks consistently appear with high participation volumes, reflecting strong organizational capacity and efficient adoption of the initiative. At the same time, federal education institutions show stable and geographically distributed growth. This contributes to the reduction of regional disparities and reinforces the role of public educational systems in supporting equitable access to interactive learning opportunities.

Finally, an important structural shift is observed over time. Whereas earlier participation growth was largely driven by a small number of highly dominant institutions, the data from 2025 indicate that expansion increasingly results from the entry of new schools rather than the continued growth of already large participants. This reduction in institutional concentration suggests a maturation of the initiative characterized by increased institutional diversity, reduced dependency on individual actors, and more sustainable expansion dynamics. From the standpoint of interactive systems, such characteristics are essential for long term viability, scalability, and inclusive impact.

7.1.1 Participation vs Medalists

Based on the collected data, the distribution of total participants and medalists by state was established to facilitate a comparative analysis of regional performance. This examination aims to identify geographic concentrations of competitors and to assess the correlation between participation volume and achieved results. Ultimately, this analysis seeks to unveil regional disparities and variations in the efficacy of student preparation strategies.

Table 7. Comparison of Registrations and Medalists by State

State	Total Registrations	Total Medalists
SP	4,775	116
CE	2,405	13
PE	2,331	2
MG	639	20
RO	535	3
SE	393	10
PB	275	2
PA	227	1
RN	199	2
RS	188	6

Table 7 reveals a marked heterogeneity in the distribution of participation and medal attainment among the analyzed states. Initially, there is a strong concentration of participants in São Paulo, Ceará, and Pernambuco. Together, these states account for more than two-thirds of the total participation volume. São Paulo exhibits a dominant position with 4,775 participants and 116 medalists and establishes itself as the primary hub for both participation volume and absolute results.

However, a combined analysis of total participation and the number of medalists demonstrates that high volume does not necessarily imply greater efficiency in securing medals. Despite having high participant numbers (2,405 and 2,331 respectively), states such as Ceará and Pernambuco display proportionally low performance regarding medalists. This is particularly evident in Pernambuco which records only two medalists. Such results suggest that factors like preparation strategies, training quality, and access to continuing education initiatives may exert a more significant influence on final performance than the mere number of participants.

Conversely, states with a lower absolute volume of participation demonstrate greater relative efficiency. Minas Gerais serves as a prime example with 639 participants and 20 medalists. This indicates a success rate considerably higher than that of states with large-scale participation. A similar trend is observed in Sergipe and Rio Grande do Sul. Even with modest participant numbers, these states achieve significant medal counts relative to their sample size. These data point to the existence of effective local preparation or selection practices possibly associated with structured educational projects or stronger integration among schools, teachers, and training initiatives.

States such as Pará, Paraíba, Rio Grande do Norte, and Rondônia present both lower participation volumes and fewer medalists. Rather than reflecting individual or collective deficiencies, these patterns are consistent with structural inequalities widely documented in the literature on access to scientific competitions and digital education in Brazil [Silva *et al.*, 2025; Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), 2023], including limited technological infrastructure in schools [Comitê Gestor da Internet no Brasil (CGI.br), 2023], reduced institutional dissemination capacity, and, as the CF-OBI participation data themselves suggest, an uneven geographic distribution of schools with active Local OBI Coordinators. These contexts represent priority targets for outreach and capacity-building initiatives that extend beyond access expansion to include pedagogical support and teacher training.

Overall, the data indicate that the distribution of medalists is not proportional to the distribution of participants across states. This reinforces the hypothesis that efficiency in training and student mentoring plays a central role in the achieved results. Consequently, the findings suggest a need for public policies and educational initiatives that extend beyond merely expanding access. It is crucial to invest in teaching quality and systematic student preparation, especially in states with large participant contingents but low returns in terms of performance.

8 Conclusion

The results presented in this study indicate that the CF-OBI is undergoing a consistent expansion process in terms of registration numbers as well as territorial and institutional reach. The growth observed specifically from 2024 onward reflects the positive impact of adopted outreach and engagement strategies. This is evidenced by the increasing interest of female students in programming competitions and their engagement with Computer Science at early stages of their educational trajectories.

However, detailed data analysis demonstrates that this growth is neither homogeneous across levels and regions nor automatically translated into active participation. The discrepancy identified between registration volumes and the number of active participants is particularly notable at the Junior level. Together with observed regional and institutional disparities, this indicates that expanding access is essential but insufficient to ensure equity. These findings highlight the need for structured and continuous actions aimed at supporting student retention, engagement, and sustained participation throughout the competition.

In this context, the results emphasize the importance of implementing complementary educational initiatives. These should promote theoretical, technological, and pedagogical preparation alongside actions focused on socioemotional development. Factors such as self-confidence, sense of belonging, motivation, and institutional support emerge as critical elements for understanding both initial engagement and the observed attrition processes. Accordingly, it is essential to further investigate the perspectives of participating students, those who do not participate, and those who register but subsequently withdraw from the competition.

The data across three consecutive editions indicate that the CF-OBI has consolidated itself as a growing and relevant initiative, with consistent expansion in participation, geographic reach, and institutional diversity. The observed patterns suggest that the competition may play a role in encouraging female inclusion and supporting the retention of girls in computing, by offering a structured, welcoming, and progressively more accessible environment for engaging with programming at an early stage of their educational trajectories. However, establishing whether these effects translate into long-term reductions in gender disparities in computing requires dedicated longitudinal studies tracking the academic and career pathways of CF-OBI participants beyond the competition itself. The continuity, refinement, and expansion of CF-OBI are therefore essential not only to consolidate the advances documented here, but also to generate the longitudinal evidence base needed to assess its broader impact on gender equity in computing education.

Finally, the findings indicate that CF-OBI provides a welcoming and strategically important learning environment that serves as an entry point for reducing gender disparities in technology-related fields. Nevertheless, achieving structural transformation requires coordinated and long-term actions that accompany students throughout their academic and professional pathways. The continuity, refinement, and expansion of CF-OBI are therefore essential to consolidate its advances, broaden its national impact, and inspire an increasing number of women to pursue and persist in Computer Science careers.

8.1 Limitations

This study presents limitations that should be considered when interpreting the findings.

First, the CF-OBI was established in 2023, and the three editions analyzed represent the complete history of the competition to date. While this means the study captures the initiative in its entirety, the reduced number of observations per level constrains the statistical power of the paired t-tests and limits the ability to distinguish consolidated trends from patterns that are still emerging. As the competition matures and new editions are held, extending this longitudinal analysis will be essential to assess whether the growth trajectories documented here are sustained over time.

Second, the analysis relies exclusively on administrative and performance data provided by the CF-OBI organizing committee. No student perception data, qualitative feedback, or teacher and institutional interviews were collected in this phase, which precludes a deeper understanding of the motivational, socio-cultural, and pedagogical factors underlying the observed patterns. Mixed-methods studies incorporating participant surveys and institutional interviews are recommended as a priority for future research.

Third, the study design does not permit causal inference. The statistical analyses establish the significance of observed growth trends and proportional differences but cannot attribute these changes to specific programme components, outreach strategies, or contextual factors external to the competition. The findings should therefore be interpreted as descriptive evidence of growth and engagement patterns, rather than as proof of the effectiveness of any particular intervention.

Finally, geographic and institutional analyses report aggregate data to mitigate re-identification risk, which means that school-level or state-level dynamics can be described but not fully explained without additional qualitative or contextual data.

Declarations

Acknowledgements

We express our gratitude to the PPGCO at UFU for their assistance. We also extend our thanks to the CF-OBI committee and the OBI for providing data from the Programming Olympiads and for their commitment to affirmative action initiatives.

Authors' Contributions

CI and CS contributed to the Conceptualization, Investigation, Methodology, Formal Analysis, Supervision, Visualization and Writing of this study. JB contributed to the Data curation, Formal Analysis, Validation and Writing. ROA contributed to Conceptualization, Data Curation and Methodology of CF-OBI. RDA and JP are supervisors guiding all the work, including the necessary revisions and adjustments. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available in `https://github.com/camilacruz-dev/dataset-cfobi`.

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