Computing for girls in elementary school in Brazil: A mapping of literature

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Abstract

The Computing field has little gender diversity, with female participation much lower when compared to men. In this context, several activities have been developed both nationally and internationally to include more women in the field of Computing. Therefore, this paper presents a mapping of the literature on computational activities with a focus on girls in elementary schools in Brazil. A systematic literature mapping process was applied, 28 papers were found with the following activities: unplugged computing, application and game development, card games, programming classes, competitions, lectures, and workshops.

Keywords

Girls, Computer, Elementary Education, Diversity, Gender

1. Introduction

Computing, in recent years, has shown itself to be an omnipresent science in society. Therefore, knowledge in Computing is as important for life in contemporary society as basic knowledge in Mathematics, Philosophy, and Physics, among others [1]. Computing content in Basic Education allows students to understand the world to which they are connected.

The Brazilian Computer Society (SBC) states that the teaching of Computing in Basic Education is fundamental because it allows students to fully understand the world, which is increasingly connected and immersed in digital technologies; improves the ability to learn and solve problems, provides new ways of expression and thinking; and serves as a tool to support the learning of other subjects [2].

On the other hand, both in Brazil and in other countries, the number of female students in Computer Science courses is disproportionate to the number of male students. In Brazil, between the years 2000 and 2013, the number of male graduates from Computing courses increased by 98%, while the number of female graduates decreased by 8% [3]. Recent data show that the number of women graduating from Computer Science courses in Brazil was 13% in 2019 [4].

In order to reduce this difference and understand why it has arisen, several initiatives have been undertaken by educational institutions. In addition, in order to encourage more girls to pursue careers in the area, SBC created the Digital Girls Program which has over 100 partner projects in different regions of Brazil. SBC also highlighted seven reasons for increasing diversity in [5].

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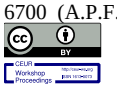

In articles such as [6] and [7], data are presented which show that students in public schools in Brasilia, the capital of Brazil, lose the desire to take computer courses when they are in the final years of high school. During elementary school, many girls still don't have a formed concept of what career to pursue. Therefore, addressing the issue of women in Computing, from their earliest school years, is a contemporary and important agenda.

Thus, this article presents a mapping of educational activities for girls in elementary school in the field of Computing in Brazil. The mapping aims to answer three research questions: RQ1) What has the distribution of articles on this topic been like in recent years?; RQ2) Which Brazilian states publish the most?; RQ3) What are the educational interventions aimed at girls in elementary school?. The methodology was based on a systematic literature mapping process. The databases used were Google Scholar, Scopus and Web of Science, and the records of the events organized by WIT-CSBC (*Women in Information Technology* - Congress of Brazilian Computer Society) and LAWCC-CLEI (Congress of Latin American Women in Computing – *Centro LatinoAmeircano de Estudios en Informática*) in the years 2010 to 2020.

The remainder of this article is divided into the following sections: Section 2 presents the methodology used; Section 3 presents the results obtained; Section 4 addresses the limitations encountered during the research process; and Section 5 concludes this article and presents some suggestions for future work.

2. Methodology

The methodology applied in this article is based on a systematic literature review process defined in [8]. The first step in mapping the literature was the definition of research questions, which were:

- RQ1) What has the distribution of articles on this topic been like in recent years?;
- RQ2) Which Brazilian states publish the most?;
- RQ3) What are the educational interventions aimed at girls in elementary school?

For the selection of articles, the following inclusion criteria were chosen:

- IC1) Has been published from 2010 to 2020;
- IC2) Is related to the theme of women in computing; and,
- IC3) Is linked to elementary school educational level.

To complement the choice of articles, two exclusion criteria were defined, which were:

- EC1) Documents that are not journal or conference articles;
- CE2) Documents with less than four pages.

The search string for choosing the relevant articles for the mapping of literature was then defined. For Google Scholar, the search *string "(Computação) AND (mulher OR gênero OR garota OR estudante)"* was used, with a publication period from 2010 to 2020. We used the string in Portuguese for Google Scholar. In this search *string*, the term “elementary school” was not used, as one of the objectives of the research was to know how many articles on the topic of women in computing in Brazil are published. Therefore, after the initial search, only articles that address activities for the elementary school level were selected. Among the academic documents found on Google Scholar, there were four graduation theses, three master's dissertations and a doctoral thesis. For Scopus and Web of Science, the *string* search *"(Computing OR "Computer Science ") AND (women OR gender OR girl OR female)"* was used and publications from 2010 to 2020.

Table 1
Number of Documents in Academic Bases on the topic in computing in Brazil.

Academic Bases	Documents
Google Scholar	82
LAWCC-CLEI	34
WIT-CSBC	82
Scopus	4
Web of Science	1
Total	203

Initially, as shown in Table 1, 82 documents were found in Google Scholar, 4 in Scopus, only 1 in Web of Science, 34 in LAWCC-CLEI and 82 in WIT-CSBC, totaling 203 academic documents. Among these articles, 194 were written in Portuguese, 8 in English and one in Spanish, the LAWCC–CLEI from 2014 and the period from 2016 to 2020 are available on their website [9], while the records for WIT-CSBC, between 2016 and 2020, can be found in SBCOpenLIB [10].

Figure 1 shows the activities carried out for the selection of articles relevant to the research questions. The first activity was the Initial Search, in which 203 documents were found. These documents were classified in a spreadsheet, with the columns: Academic database (Google Scholar, Scopus, Web of Science, LAWCC-CLEI and WIT-CSBC), Title, Author(s), Year of publication, Institution, Type (article, graduation, dissertation of master's or doctoral thesis), Type of article (conference or journal), State and Educational Level (elementary, high school, undergraduate, master, doctoral).

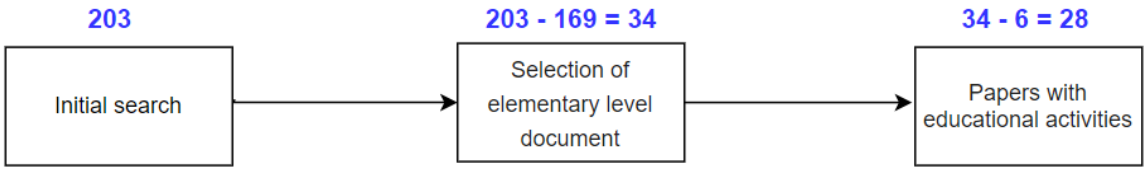

Figure 1: Steps of the methodology used and the number of publications.

The data collection process was divided into two phases. In the first phase, titles, authors and article abstracts were collected; in the second stage, all articles were read and analyzed. Using the exclusion criteria and considering only the articles that addressed elementary education, from a total of 203 articles, 34 were filtered. Most of the 203 articles are about activities in secondary education. Of the 34 articles from elementary school, a new analysis of the articles was performed and 28 contained educational activities for girls, thus, 82.35% presented some educational computer intervention for elementary school students. The answers to research questions RQ1 to RQ3 were consolidated after the second phase and are presented in the next section.

3. Results

The purpose of this section is to present the answers to the three research questions defined in this article.

3.1 RQ1) What has the distribution of articles on this topic been like in recent years?

Figure 2 shows the distribution by year of publication of the articles found. The survey was conducted between 2010 and 2020, but the first articles found with educational activities for girls in

elementary school were only published in 2016. Of the four articles from 2016, two were in WIT-CSBC, one in CLEI-LAWCC and one at the CBIE (Brazilian Congress on Educational Informatics). Since then, the number of articles has grown, with 2020 being the year with the most publications, totaling 13 articles, that is, 38.23% of the total number of articles collected.

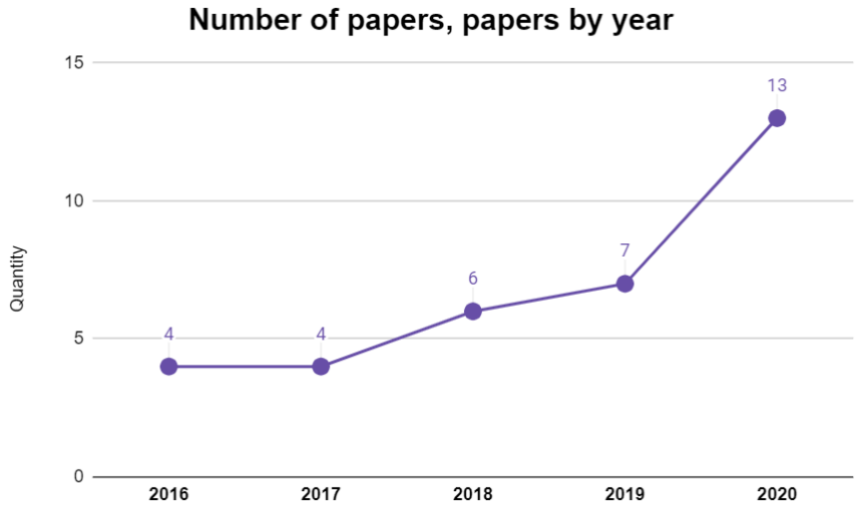

Figure 2: Number of papers per year.

An important point that may have contributed to this increase is the national discussion on the changes to guidelines in elementary education in Brazil, in which computing has been analyzed as an important issue for the education of elementary and high school students. In addition, the WIT-CSBC event, which had its first edition in 2007, began publishing the activities in academic articles as of 2016.

3.2 RQ2) Which Brazilian states publish the most?

The second research question "Which Brazilian states publish the most?", aims to assess the density of publications by Brazilian state. This is a relevant analysis given the fact that Brazil is a country with regional, cultural and social differences.

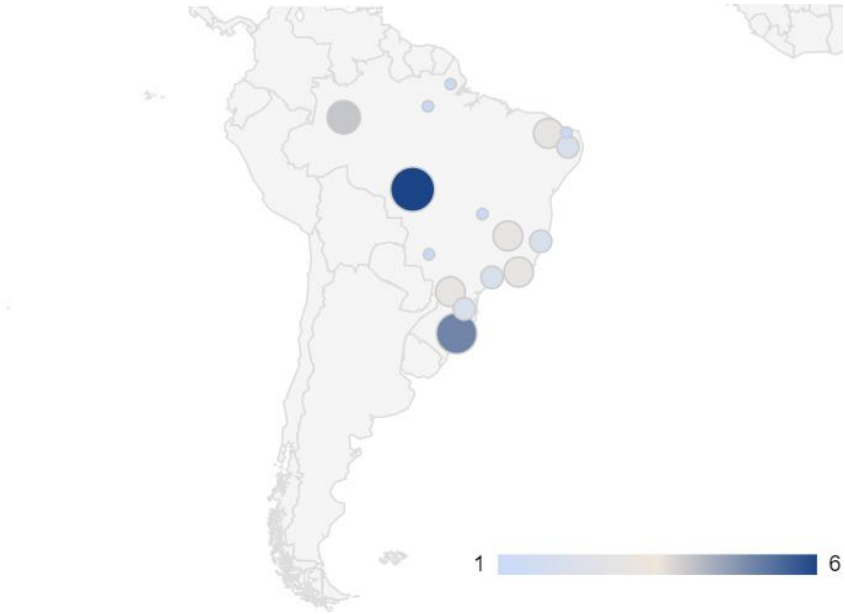

Figure 3: Density of publications by state.

Figure 3 shows the Brazilian states that published most articles on the topic of girls in elementary school with a focus on computing. The three states with the highest number of publications in descending order are: Mato Grosso, Rio Grande do Sul and Amazonas. The State of Mato Grosso had the highest number of publications, 6 articles, published by authors from the Federal University of Mato Grosso and the Federal Institute of Mato Grosso. This is followed by the State of Rio Grande do Sul with 5 articles, at the institutions of the Federal University of Rio Grande do Sul, Federal University of Pampa and Regional Integrated University of Alto Uruguai e das Missões. Finally, we have the state of Amazonas (4 articles) in the institutions of the Federal University of Amazonas and the State University of Amazonas.

However, when it comes only to articles with educational activities, the states of Amazonas, Rio Grande do Sul and Mato Grosso have the same number of publications with 4 articles published. Next are the states of Minas Gerais, Paraná and Rio de Janeiro with three articles each.

In this mapping, it was possible to identify publications in all Brazilian regions. The regions that had the most publications were the South and Southeast, with 10 publications each. Then there is the Midwest Region with 8 articles, Northeast and North with 6 articles. This distribution can be easily visualized in the heat map in Figure 3.

3.3 RQ3) What are the educational interventions aimed at girls in elementary school?

In order to answer the main research question of this paper, the educational activities carried out for girls in elementary school, and described in the articles found, are presented. From Table 2 it is possible to have an overview of the activities covered in the collected articles. Among them, the most prominent are Unplugged Computing (10 articles) and Workshops (9 articles).

Table 2
Activities educational in Elementary School.

Activity	Document
Unplugged computing	[11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21]
Workshop	[22] [23] [24] [14] [17] [18][19]
Programming Classes	[14] [25] [26]
Development of Games	[27] [28] [14] [25] [19]
Competitions	[27] [28] [14] [25] [19]
Code.org	[32] [33] [34]
Games Card	[35] [14] [19]
Inventor app	[30] [19] [14]
Arduino	[14] [26] [19]
Motivational Speeches	[36] [30] [15]
Design Thinking	[30] [25]
Learning of Circuits Electrical	[14] [26]

Table 3 presents a summary of the unplugged activities. Articles [12] and [14] presented unplugged activities related to binary numbers. In [13] algorithm writing activities in the context of everyday tasks such as baking a cake, putting on makeup and walking from home to school were presented. [16] presented an activity on the representation of digital images using paper plates, [17] used cards and a magic trick approach to illustrate information transmission errors. In order to introduce basic programming concepts, [18] reports on an activity for programming on paper. Other similar activities were described in [11], [19] and [15].

Article [21] brought computational thinking activities through *Moodle de Lovelace* for deaf girls. Article [20] also presented computing Unplugged activities on databases and computational thinking

for teachers of Basic Education. The latter activity is a very important initiative as the training of teachers is critical to the realization of computing activities in elementary and high schools.

In relation to Workshops, many initiatives were also found. [23] presented workshops associated with a sculpture by Ada Lovelace in which participants were able to disassemble a computer, learn about its physical parts and create an artifact using the disassembled parts. In [24] a Human Computer Interaction workshop was presented evaluating a messaging application; Web 2.0 tools and block programming workshops were presented in [18]. Several workshops were presented in [14], among them a podcast and a comic book workshop, robotics, Arduino and 3D printing.

Three articles were also found that described programming classes. [25] showed the work experience of the SuPyGirls project, which presents the results of using *Design Thinking* and computational thinking to build a game and teach programming. Among the activities presented in [14], one of them describes specific programming workshops that used the HTML and Python languages. Finally, [26] presents a theoretical-practical course containing programming logic, classes on electrical fundamentals, Arduino, among others.

Table 3

Unplugged Programming Activities.

Theme	Document
Binary numbers	[12] [14]
Algorithm writing in the context of everyday activities	[13]
Representation of digital images using paper plates	[16]
Magic trick to illustrate information transmission errors	[17]
Programming on paper	[18]
Computational thinking through the *Moodle of Lovelace* for deaf girls	[21]
Activities on database and computational thinking for Basic Education teachers	[20]
Others	[11] [19] [15]

The article [15] reports on a *Hackathon* that set the challenge of developing, using the Figma tool, a prototype application that would promote the education of girls and women in areas of social vulnerability. [29] and [31] relate to the *Technovation Challenge* [37], for high school and elementary school students, which consists of a competition to create applications aimed at a social cause. The first article described the experiences of students from Mato Grosso do Sul in the competition, while the second presented a case study of the 2017 edition, using questionnaires to extract data and analyze the Brazilian participation in the event. Another competition was also described in [30], at the *Technovation Hackday* event held by the Institute of Mathematical Sciences and Computing at the University of São Paulo. In this, the participants also developed applications, and in addition the event presented some lectures, including one on *Design Thinking*.

Game development is another common application of computing, and this type of activity was also found in some articles (Table 4). [27] presented the activity “Little Computer Scientists" for children from 4 to 7 years old, which involved the development of a game, using Scratch Jr. [38]. However, before developing the game, an opportunity was created for immersion and socialization of the children. Similarly, the Game Maker tool was proposed to develop the Breakout game for students in the sixth and eighth academic years at a public school in Rio Grande do Sul in [28]. A game development workshop using the KODU tool was described in [14], furthermore a paper prototyping was performed. In the activity presented in [25], the girls decided on the theme of the games developed and used the Python language for implementation after going through digital literacy. Another activity of the same kind was mentioned in [19] using the Scratch tool [38].

For educational activities related to mobile application development, the AppInventor tool is usually used. It has an intuitive interface which allows the game to be developed through components and blocks, facilitating the creation of a mobile application even without having much knowledge of programming. Three articles were found that bring activities with games to elementary school girls. In [19] the students were instructed to develop a game using the AppInventor. In [30], AppInventor was

the platform used for development in the *Technovation Challenge* described in the article. Among the activities presented in [14], one of them is a mobile application development workshop in which the same platform is used, with the target audience being girls of 8 years old or older.

Table 4
Tools used in Game Development activities.

Tool	Documents
Scratch Jr.	[27]
Scratch	[19]
Game Maker	[28]
KODU	[14]
Language Python	[25]

The Code.org tool is used worldwide for teaching Computing in an easier way. In Brazil, three articles were found that used this platform with the issue of gender and elementary education specifically. One of these articles, [34], presents the experience, carried out by the project Meninas Digitais do Vale, of introducing concepts of programming logic using the Code.org platform in a class of 91 students, 45 of whom are girls. [33] reports on the experience of a workshop, carried out by the Projeto Meninas Digitais Regional do Mato Grosso, to introduce programming based on Code.org activities, with children aged 7 to 12 and their families. Finally, [32] also presents a workshop introducing basic programming concepts for girls in elementary school, in this case high school too, using Code.org.

As presented in this section, Brazil has many educational activities for girls in elementary school in Computing, which are aligned with tools that are applied worldwide.

4. Limitations

This work was based on academic articles published in conferences and in journals. Thus, it was not possible to capture educational initiatives in elementary education for girls in Computing that were not published in conferences or magazines. It was also not possible to include the articles from CLEI 2015, as they were not available for access.

To reduce the bias in the exclusion of articles, weekly meetings were held in order to analyze the conflicts between researchers involved in mapping the literature. As mentioned above, these comprised a professor who is a researcher on the subject of women in Computing and
three undergraduate students from the Department of Computer Science at the University of Brasília.

5. Conclusion

As shown in this literature mapping, the number of educational activities for students in elementary school, with a focus on gender diversity in computing, has been increasing since 2016, with a sharp increase in the year 2020. Events such as LAWCC-CLEI and WIT-CSBC have a fundamental role in publicizing the activities carried out in Brazil.

Although Amazonas and Mato Grosso are among the states that published the most activities for elementary education in this literature mapping, if we look at the Brazilian regions, the South and Southeast regions are highlighted, which is not new, since these regions have the greatest number of universities in Brazil. Most of the activities are partner projects of the *Meninas Digitais* of the Brazilian Computer Society.

Among the activities presented, Unplugged Computing was highlighted, and this may be related to the social issues in Brazil, since many public schools do not have a good infrastructure of Computing laboratories. However, there were also activities with Scratch, App Inventor, Coed-org which are worldwide platforms used for teaching Computer activities at elementary school level.

As future work, it is intended to do a literature review analyzing the effectiveness of these activities in elementary education. The idea of the review is to identify the impact caused by these activities in terms of reducing the gender diversity gap in computing.

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