A Mapping Study of Computational Thinking and Programming in Brazilian K-12 Education

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***Abstract*—This research full paper characterizes the literature on academic initiatives to foster computational thinking and programming (CT&P) in Brazilian K-12 education. Context: Mapping and analyzing the diversity of experiences and studies that address CT&P in K-12 education can bring valuable data to researchers. This work delimits such study to the Brazilian scenario to allow a more in-depth view, given the Brazilian context. Previous surveys and systematic mapping studies present recent publications in major Brazilian computing journals and conferences. Although they offer important contributions, they do not comprehensively cover the Brazilian literature on CT&P in K-12 education, since they focus the search in the Brazilian Computer Society publications alone. Objective: This work proposes to characterize the literature on CT&P in K-12 education in Brazil. Results: through a systematic mapping study, we collected information on year, venue, type, K-12 education stage and modality, methodological contexts, and used tools and programming languages from 338 selected primary studies from 2001 until 2016. Conclusions: there is a significant increase in the number of Brazilian studies in the latest years, showing a growing interest on this research area as well as several trends and gaps to be addressed by both researchers and practitioners.**

I. Introduction

Contemporary world undergoes an intense technological evolution. In this process, computing is a great propeller, expanding possibilities and enabling the implementation of new ideas. This makes it a science of great relevance to today's society and has motivated initiatives around the world to introduce computing as a science for all. One of the strategies for disseminating computing is including it as part of the K-12 curriculum. In 2006, Wing stated the relevance of everyone knowing computing [1]. She coined the term computational thinking (CT) to name a set of thinking skills usually developed by computer scientists. In addition, she asserted that those skills compare to the ability of reading, writing and performing arithmetic operations. Barr and Stephenson added that students shall work in fields influenced by computing and shall deal with computing in their daily lives [2].

In the United States, curriculum frameworks were created to support computing education in K-12 education. These frameworks encompass concepts and computational practices that provide a solid background for both students who want to deepen their computing knowledge as well as those who will use such concepts in other fields [3], [4]. In Israel, academics have developed a curriculum model for high school in the 1990s [5]. The model had two versions, which varied according to students' interest in pursuing studies in the field. United Kingdom, New Zealand, Germany, India and South Korea also introduced computing into their high school curricula [6]. These countries recognize that adding computing to K-12 education has a direct impact on their development.

In Brazil, similar initiatives have also emerged. In 2004, the Brazilian Computer Society (SBC) discussed the possibility of introducing computing, especially programming, in high school [7]. Since then, initiatives have emerged with the aim of introducing computing by teaching algorithms and programming. With the worldwide spread of ideas on computational thinking, the number of initiatives in Brazil is increasing [8]. Recently, SBC created references for computing in K-12 education [9].

Mapping and analyzing the diversity of experiences and studies that address computational thinking and programming (CT&P) in K-12 education may reveal important information, answering relevant questions that may contribute to the advancement of the field and reassert the need of integrating CT&P in the K-12 curriculum. Delimiting the study to the Brazilian scenario allows a more in-depth view given the particularities of the Brazilian context. In research, a method widely used to derive an overview of a particular field of study is the systematic mapping study (SMS) of the literature, which provides descriptive answers to given research questions [10], [11].

Previous surveys and SMS have already addressed the theme proposed in this paper [8], [12]–[16]. They present recent publications in major Brazilian computing journals and conferences. Although they offer important contributions, they do not comprehensively cover the Brazilian literature on CT&P in K-12 education, since they focus the search in SBC publications alone. We believe that a search beyond these publications is needed to derive a more accurate picture of the Brazilian reality on this topic, since various teachers and researchers usually publish in other education-related venues. This work proposes to more comprehensively characterize the literature on CT&P in K-12 education in Brazil.

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II. Methodology

An SMS has well defined procedures and steps. In this work, we consider the steps suggested by Petersen et al. to carry out the study [10]. The steps performed were: defining research questions, searching primary studies, selecting relevant studies, defining a classification scheme, and extracting and mapping data.

A. Defining Research Questions

The research question that guided this work is:

RQ1. ***How do Brazilian initiatives teach CT&P in K-12 education?***

With this question, we intend to know the methods, tools and languages used to teach CT&P and which stages of K-12 education those studies have focused in. To this end, we defined three secondary research questions that are presented below.

RQ2. Which stages or modalities of education have the studies focused in?

Brazilian K-12 education, known in Brazil as *Basic Education*, is split into different stages: childhood education (up to 5 years-old), fundamental education (level I – grades 1 to 5, and level II – grades 6 to 9), and high school (grades 10 to 12). Moreover, it has additional modalities for particular situations: special, vocational, distance, and youth and adult education. We want to know how the teaching and research effort in CT&P is split into the stages and modalities of Brazilian K-12 education.

RQ3. Which particular methodological contexts or domains have been used to illustrate CT&P?

CT learning, as well as programming, is usually considered to be cumbersome and complex. One of the strategies adopted to make it easier and friendlier is the use of meaningful contexts for students. With this question, we want to know which methodological contexts are being used by the Brazilian teaching and research initiatives.

RQ4. Which tools and programming languages are being used to develop CT&P skills?

Several tools have been used or suggested to teach CT&P in K-12 education. We want to know which ones are being used or suggested by the initiatives in Brazil.

B. Searching Primary Studies

The search step happened in November 2016. Search was both automated and manual. In the former, we searched Google Scholar, and retrieved 3968 studies. We also searched the Special Committee on Computers in Education (CEIE) Publications Portal, that covers some of the main journals and conferences on Computers in Education published by SBC, and retrieved 126 articles. The search string was composed of two blocks of words in Portuguese: one with words related to the term "computational thinking" and another with words related to the term "K-12 education". Table I presents a compact version, in English, of the Portuguese string we used in the automated search. Some terms, often used to refer to Brazilian K-12 education, its stages and modalities, are not presented in the table, but were used during the search for more comprehensive retrieval. In the manual search, we looked through the papers published between 2001 and 2016 in the Workshop on Computing Education (WEI), a relevant venue in the field that is not entirely indexed in search engines, and retrieved a total of 14 papers.

This step returned 4108 articles. 2090 of those were duplicates, which resulted in a total of 2018 potentially relevant articles in the search step.

Table I
Search String, translated to English for clarity

("computational thinking" OR "computational reasoning" OR intitle:"computing" OR "programming logic" OR "teaching programming" OR "learning programming")
AND
("K-12 education" OR "basic education" OR "fundamental education" OR "childhood education" OR "high school" OR "technical vocational education")

C. Selecting Relevant Studies

To perform the selection step, we read title, abstract and keywords of the studies retrieved in the search phase, and used inclusion and exclusion criteria afterwards. When titles, keywords and abstracts did not provide enough information, we had to read other parts of the paper. Two reviewers concurrently carried out the selection, and the divergences were solved by a third reviewer. The excluded studies fell into one of the following criteria: they addressed the use or development of tools for purposes not related to CT&P education; the were available only as abstracts, they had less than 3 pages, considered as extended abstracts; they were not applied in the Brazilian context; they were not published in journals or conferences; they were not primary studies, e.g., either systematic reviews or SMS; they were not academic papers; or they did not meet the inclusion criterion. The criterion for inclusion of the studies was: *to approach teaching or learning of CT&P in Brazilian K-12 education*. The selection step resulted in 388 included primary studies.

In this step, we also gathered some information that allowed building a scheme to classify the data in the primary studies.

D. Classification Scheme

From previous readings as well as from the titles, keywords and abstracts of the selected studies, we devised a scheme to classify them into different facets: study type, context, used tool, used programming language, and stage and modality of K-12 education. Below we describe each classification facet and present the categories used to classify the data. The classification scheme was defined to achieve the goals of this work.

1) Study Type: characterizes the nature of the study in experience report, case study, action research, experiment or quasi-experiment, survey, opinion article, solution proposal, philosophical article;

2) K-12 Education Stage/Modality: we considered the stages and modalities of Early Childhood Education (up to 5 years-old), Fundamental Education (grades 1 to 9), High School (grades 10 to 12), Special Education, Youth and Adult Education (EJA), Technical Vocational Education, and Distance Education;
3) Methodological Context: medium and approach where the content of CT&P is presented to provide both more meaningful understanding and student motivation. We used the following categories: traditional, robotics, games, hardware, unplugged and animations and stories;
4) Tool: several tools are used to support teaching CT&P. We considered the following: Scratch, App Inventor, Greenfoot, BlueJ, Alice, Robocode, Code.org, Lego robots, IDEs, Arduino, VisuAlg, KTurtle, Blockly and own tool (i.e., when authors have developed their own tools);
5) Programming language: teaching CT is frequently done while teaching programming. We used the following languages to categorize studies: Python, C, C++, Java, JavaScript, Pascal, Logo, Wiring, block language and pseudo-code.

For completeness, we added categories to some facets such as: other, not applicable, unmentioned and unspecified.

E. Data Extraction and Mapping

In this step, we analyzed the 389 included studies during selection, and collected the data according to the classification scheme. We also extracted title, location, and year of publication. During data extraction, we found 5 duplicates, and, after a more thorough reading, we also excluded 46 papers that we realized did not match the inclusion criterion. At the end of this step, there were **338 primary studies** that contributed to this SMS. When extracting data, we considered only the information described by the authors in the text in order to reduce subjectivity. The final list of selected papers is available elsewhere[1].

III. Results

In this section, we present the SMS results and provide answers to each research question.

A. Overview

It seems important to us to understand the nature and trends of the studies on CT&P in Brazilian K-12 education. Thus, we collected data on paper type, venue, and publication year.

From the data reported in Figure 1, we notice that the number of studies grows considerably in 2010 (19), reaching the largest numbers in 2015 (86) and 2016 (81). Nonetheless, we have also identified papers published before 2010.

Workshops concentrate the largest number of publications, especially on themes like computers in school (WIE – 58), computing education (WEI – 53) and computers in education (CBIE workshops – 41). The RENOTE journal, on the other hand, has the largest number of published journal papers (13), followed by RBIE, an SBC publication on computers in education. In addition to the main venues, we found more than 95 venues with publications on CT&P, showing a large spread of publications in regional forums. In Figure 2, we present the numbers for the venues with at least two publications until November 2016.

[1]https://sites.google.com/site/fie2018mapping/

Table II
Study Type (adapted from [17] and [18])

Category	Description
Experience report	Describes the authors' personal experience using a particular approach, explaining what and how something has been done in practice. It usually includes lessons learned.
Case study	An empirical inquiry that investigates a phenomenon within its real-life context. Paper may deal with single or multiple cases, include quantitative evidence, rely on multiple sources of evidence, and benefit from prior development of theoretical propositions.
Action research	Interactive inquiry process that balances collaborative problem solving actions with data-driven analysis or research to understand underlying causes, enabling predictions about personal and organizational change.
Experiment or Quasi-experiment	A collection of research designs that use manipulation and controlled testing to understand causal processes. Generally, one or more variables are manipulated to determine their effect on a dependent variable.
Survey	Encompasses measurement procedures that involve asking questions of respondents, generally by sampling them from a population, usually by questionnaires or interviews.
Opinion paper	Expresses the personal opinion of someone about a certain approach, or how things should been done. Does not rely on related work and research methodologies.
Solution proposal	A solution for a problem is proposed, either novel or a significant extension of an existing technique. Potential benefits and applicability of the solution are shown by an example or argumentation.
Philosophical paper	Sketches a new way of looking at existing things by structuring the field in a taxonomy or conceptual framework.

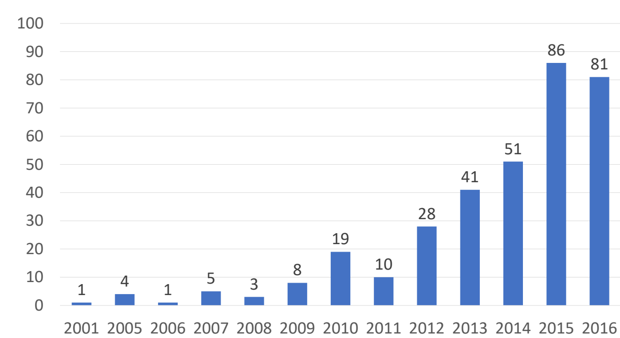

Figure 1. Papers per Year

Table III
STAGES/MODALITIES OF BRAZILIAN K-12 EDUCATION

Category	Description
Early Childhood	Receives children from 0 to 3 years-old in daycare and children from 4 to 5 years-old in pre-school.
Fundamental	Starts from age 6, lasts nine years, and is split into two levels: initial grades (1 to 5), and final grades (6 to 9).
High School	Last stage of Brazilian K-12 education, lasts three years. Aims to provide students with basic background and to prepare them for the marketplace or to pursue further studies.
Special	Modality designed to meet students with disabilities, global developmental disorders and the highly skilled or gifted.
Youth and Adult	Modality organized to meet students who did not study at the proper age.
Technical Vocational	Modality geared towards qualification for work. It occurs both through technical and vocational programs.
Distance	Modality where teaching and learning activities occur when those involved are physically separated.

Table IV
CONTEXT

Category	Description
Traditional	Content is presented using the traditional way of giving lectures, usually focusing on algorithms to solve mathematical problems.
Robotics	Content is presented while students are in touch with robotics concepts and practices.
Games	Students are involved in practices of game development or use.
Hardware	Students work with code to control hardware such as LEDs, engines, sensors and others.
Unplugged	Computational thinking skills are practiced with playful activities without using a computer.
Animations and Stories	Students are encouraged to create animations and stories through tools that allow the development of CT&P skills.

The most popular paper type is the experience report (193), but we identified a large number of solution proposals (56), case studies (55) and experiments or quasi-experiments (17). Paper type numbers are shown in Figure 3. Empirical studies with appropriate research methods amount to 23.5% of the studies (80 out of 339), showing an increasing trend in the latest years. Among them, a case study was conducted in 2015 to asses the game "The Foos" as a tool to teach CT concepts [19]. Authors analyzed the "understanding of interface elements" and "conceptual understanding of PCs" when students played the game. In the same year, a quasi-experiment was carried out to verify the existence of a relationship between student performance in the National High School Exam (ENEM) and their programming skills [20]. Using a sample of 103 students, they found a moderate correlation between the variables. It is also worth mentioning a survey conducted to measure the knowledge of graduates from Computing teacher

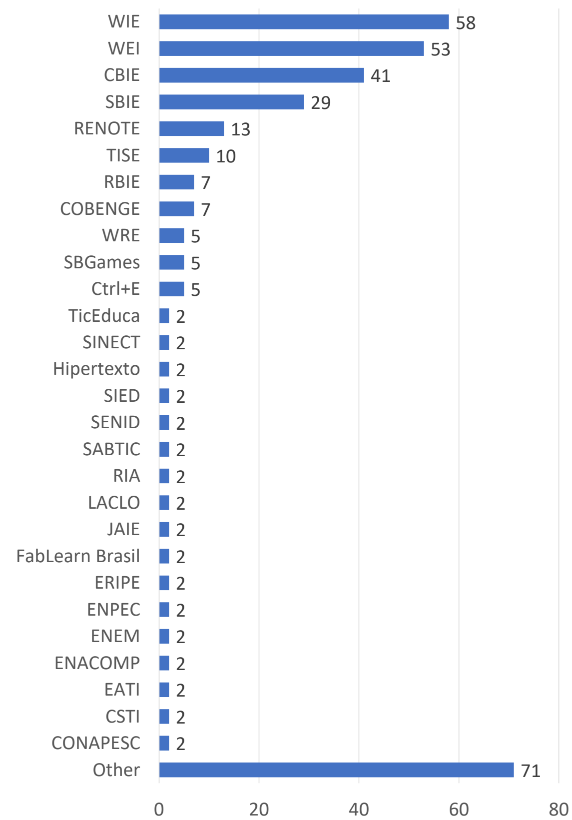

Figure 2. Papers per Venue

training programs on the topic of CT [21]. Results showed a detachment between program content and CT subject matter, as well as little conceptual knowledge by the students.

Figure 3. Papers per Study Type

B. Stages/Modalities of K-12 Education

Among the stages and modalities we considered, we identified a larger number of studies both in High School (147) and in Fundamental Education (140). However, Technical

Vocational Education also showed a large number (82) of studies. Figure 3 describes the panorama of this dimension in more detail.

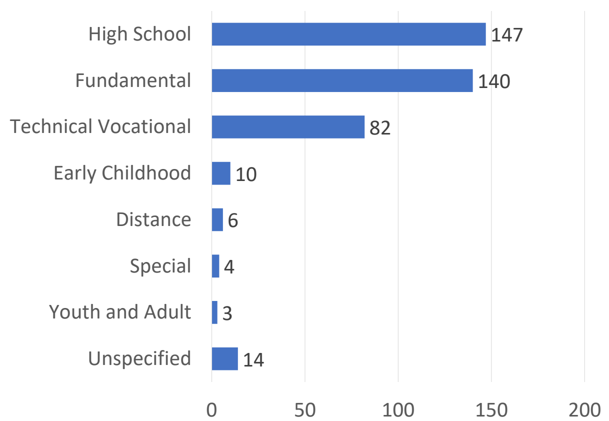

Figure 4. Papers per Stage/Modality of K-12 Education

Integration with other subjects is presented in a study where 8th and 9th grade students of fundamental education developed Scratch stories on the theme of "Environment and Sustainability" [22]. Researchers observed that creating stories using Scratch allowed developing important life skills, and motivated them to learn. Among the few studies that discussed computing in the Youth and Adult Education modality, we highlight one that aimed to analyze the impact of introducing CT given the challenges with this public, scarcely served by proposals that approach the theme [23]. From observations of CT activities and interviews, authors noticed positive results including the reduced student resistance to better understand computational processes. Another work, carried out with students of the technical vocational computing program, proposed the use of learning objects' ateliers to motivate students to learn programming concepts and languages [24]. As a result, they observed that the approach aroused autonomy and contributed to students' motivation and engagement.

C. Methodological Contexts

Games (125), which cover both game use and development, and Robotics (89) were the most used contexts by the mapped initiatives. In addition, we found a large number of experiences with Unplugged Computing (42). In the "Other" category (48), a number of studies usually present experiences with development of applications for mobile devices, hands-on activities, development of learning objects, among others. Figure 5 shows the distribution of papers per context.

One of the studies in the Games category discusses game development with the Scratch tool as a way to learn math [25]. Students went through some steps from learning the tool to developing projects with mathematical challenges. Through interviews and analysis of developed projects, authors perceived satisfactory results regarding the growing interest of students in the projects. Another work proposed the use of the game "City of Bits" to learn fundamentals of computing in

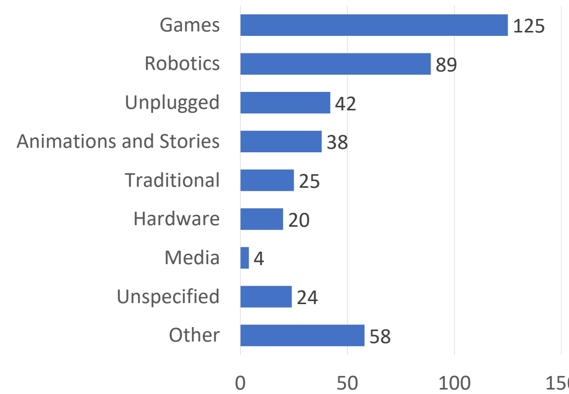

Figure 5. Papers per Context

High School [26]. In the game, students answer questions and decipher puzzles on the subject to score and prevent the enemy from conquering the City of Bits. A less common context was Hardware. With this context, we highlight a work developed using Arduino to teach programming languages and to develop CT skills with technical vocational education students. Pairs of students received kits with items needed to assemble circuits with Arduino, and simulated real scenarios through paper prototyping and LED control. Authors realized that students had less learning difficulties and showed engagement during the activity.

D. Tools and Languages

The most commonly used tools were Scratch (102), Lego Robots (40) and Arduino (38). In addition, we found that a large number of studies worked with other tools (125). We also identified that there is a number of studies (39) with own tools developed by Brazilian authors for teaching CT&P. Figure 6) shows these data in more detail.

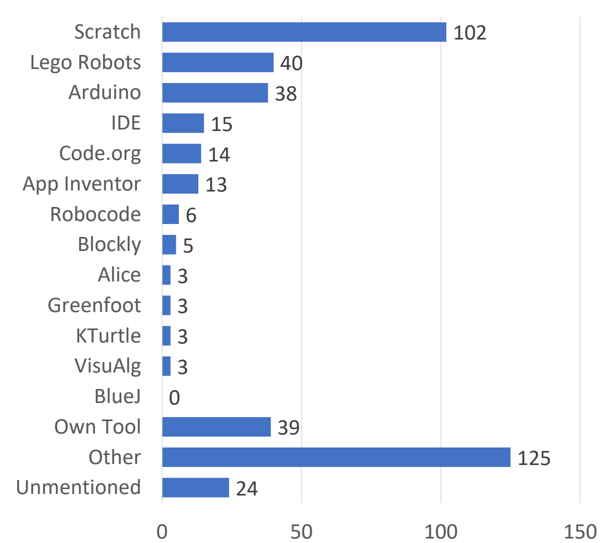

Figure 6. Papers per Tool

One of the goals of Brazilian researchers bringing computing to K-12 education is to uncover talents in the field. With this aim, a work was developed in high school using Scratch and App Inventor tools [27]. Students were introduced to programming with Scratch and deepened their knowledge by developing applications in App Inventor. Results were positive since a large number of students who participated in the project demonstrated interest in joining computing undergraduate programs. Another work used the Scratch tool and project activities in Code.org [28]. Students performed various logical reasoning activities and collaboratively developed Scratch animations and games. The project helped children to develop problem solving skills.

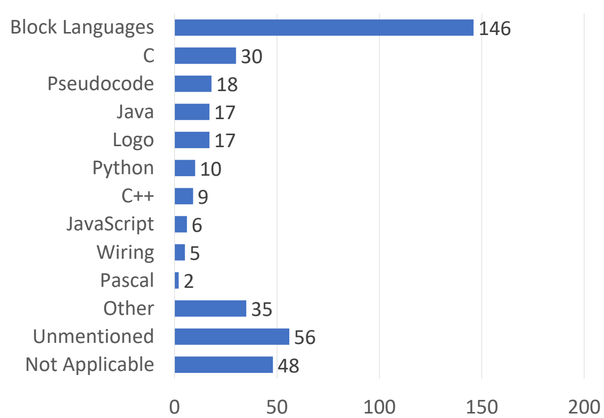

Figure 7. Papers per Language

The programming language that most stood out was block language (146), followed by the C language (30). On the other hand, the popular Python language (10) was scarcely present in the selected papers. Figure 7 shows the number of studies found for each language. In the block language category, an interesting work presents an environment with a block language to code the Arduino board [29]. Developed to teach children programming, the environment, called *DuinoBlocks4Kids*, provides a user-friendly interface for programming LEDs, engines, displays and sensors. In a workshop, a group of elementary school students used the robotics environment to learn programming concepts. Authors stated that workshop results showed that *DuinoBlocks4Kids* is a good option to develop some CT skills with children in the early years of elementary school.

E. Tools versus Stages/Modalities of K-12 Education

Table V shows how frequent each tool is used per stage/modality[2] of K-12 Education. We notice that the use of Scratch reduces as the education level progresses, with Fundamental Education as the significant starting point. We conclude that the use of this tool has been more frequent with students between 6 and 14 years old, most likely due to its playfulness. On the other hand, we notice that tools like Lego Robots or Arduino have been more used than Scratch during High School. Despite the relevance of the Code.org tool for Early Childhood Education, we have not identified papers using this tool at this stage.

Table V
TOOL VERSUS STAGE/MODALITY

Tool/Stage	E.C.	Fund.	H.S.	T.V.	Sp.	Y.A.	Dis.
Scratch	2	54	38	19	0	2	1
App Inventor	0	2	12	1	0	0	0
Greenfoot	0	0	0	2	0	1	1
BlueJ	0	0	0	0	0	0	0
Alice	0	0	0	1	0	0	0
Robocode	0	1	2	4	0	1	1
Code.org	0	11	7	0	0	1	0
Lego Robots	0	17	20	7	0	0	0
IDE	0	3	7	8	1	0	0
Arduino	0	17	19	15	2	0	0
VisuAlg	0	1	1	1	0	0	1
KTurtle	0	3	1	0	0	0	0
Blockly	0	2	0	2	0	0	0
Own Tool	2	14	16	13	1	0	0
Other	7	63	51	23	2	1	1
Unmentioned	0	5	14	8	0	0	3

F. Methodological Contexts versus Stages/Modalities of K-12 Education

Table VI[3] shows a significant reduction of the use of Games in High School when compared to Fundamental Education. We also observe a large focus of Unplugged Computing activities in Fundamental Education. In Technical Vocational Education, the contexts of Games, Robotics and Traditional Approaches stand out.

Table VI
CONTEXT VERSUS STAGE/MODALITY

Context/Stage	E.C.	Fund.	H.S.	T.V.	Sp.	Y.A.	Dis.
Traditional	0	6	14	10	0	0	3
Robotics	6	37	40	25	1	0	0
Games	6	59	47	28	1	1	1
Hardware	0	8	14	6	2	0	0
Unplugged	1	29	16	1	0	1	0
Animations	2	25	13	7	1	0	0
Media	1	1	3	0	0	0	0
Other	1	25	27	11	1	1	0
Unmentioned	0	3	11	8	0	1	2

IV. DISCUSSION

In Brazil, in-depth studies on the topics of CT&P in K-12 Education still account for a smaller share of the studies found. Most selected studies are experience reports described in workshops. Nonetheless, selected case studies, surveys and experiments/quasi-experiments point to a growing trend of empirical evaluation on this subject, and also that progress has been made over the years. Researchers are perceiving this area as a promising field of research and gradually increase their investment on it.

The work on CT&P in Brazilian K-12 Education is concentrated in High School and in regular Fundamental Education.

[2]See full description of stages/modalities in Table III.

[3]See full description of stages/modalities in Table III.

We also identified, as of 2015, a reduction in the number of experiences in High School and an increase in the number of papers directed towards Fundamental Education. Much of the work in high school was motivated by the need of IT professionals, and aimed to arouse students' interest in computing. In contrast, the studies in Fundamental Education were more interested in investigating the development of thinking skills through computing knowledge. On the other hand, earlier years of elementary school account for the smallest share of the total number of studies in that category. Early Childhood Education and Youth and Adult Education are also lacking research in the topic of CT&P. It is though interesting to point out that, regardless of its scarcity, the modality of special education already counts with academic work that stimulates computational thinking.

We note that the methodological contexts of Games, followed by Robotics, are predominant to teach CT&P in Brazil, in the various stages and modalities of K-12 Education. This also relates to the predominance of the Scratch tool, used in most studies that deal with the development of games, animations and stories. As well as the use of Lego Robots and Arduino boards in the contexts of Robotics and Hardware, respectively. Furthermore, it is worth highlighting that tools are being developed in Brazil for the purpose of teaching CT to young students of K-12 Education. In the languages facet, we highlight the use of block languages based on the idea coding by fitting blocks, just like Lego toys. In addition to the Scratch environment, tools like Lego Robots, App Inventor and others make use of this type of language, which justifies its predominance over other languages.

On the other hand, we also identify contexts, tools and languages that have not been thoroughly explored. In terms of contexts, among those we listed, the least explored is Media. With the increasing use of sounds, images and videos in online social networks, using this context may attract and motivate students to learn. Traditional approaches, even in small numbers, appear in recent years and are mostly used in the modality of technical vocational education. Among the tools, several are present in a smaller fraction of studies, such as Greenfoot, Kturtle and Alice. BlueJ did not show up in any selected work, and one likely reason is the rare number of studies addressing object-oriented programming in K-12 Education.

We observed a large number of academic studies that do not follow strict research methods. We believe this is one of the reasons for the concentration in the classification facets we derived. A large number of Brazilian scholars tend to replicate experiences that were already proven to work, while giving in to research into strategies to introduce computing in K-12 education. Moreover, even though there is a fair number of studies on unplugged computing and a couple of projects with hands-on activities, we realize that programming has been the main means used to develop CT skills. Thus, there is also a lack of research that investigates other ways different from programming to develop CT skills with K-12 students in Brazil.

A. *Brazil in the International Context*

In terms of CT&P education, Brazil lags behind other countries such as the United States, Israel, New Zealand and the United Kingdom [30]. While these countries presently seek to consolidate their educational practices, in Brazil the experiences are mostly focused on involving students with computing, and showing the benefits of knowing computing to enable and facilitate its formal introduction in K-12 education. Regarding tools, Brazilian experiences follow the trend of other countries with the frequent use of Scratch in their approaches [31], [32]. The use of Games and Robotics as the main contexts to teach computing in K-12 education is also in line with other countries' experiences [32].

When analyzing the efforts, we realize that despite the various experiences, Brazil still needs to make significant progress regarding both quality and depth of the process of teaching and learning computing in K-12 Education. There seems to be a lack of concern to the pedagogical foundations that may compromise the results of those efforts. We realize there is an intense concern with how computing is presented to attract student attention, but there is little concern as to whether the used approach is effective for learning. It is important that students enjoy the approach, which facilitates learning, but this alone is not enough. Reflecting on the quality of the process of teaching and learning computing is essential to the effective introduction of computing in K-12 education to reach a real impact on the country's technological advancement. Another drawback we found relates to teacher training. Results of a study we found point out that future computing teachers had little or even no knowledge of the concept of CT [33]. This shows the need for training to be in line with the recent discussions and proposals in academia.

From the analysis of the Brazilian scenario, we suggest that countries in the initial steps of introducing computing in K-12 education, such as Brazil, invest in approaches that are both attractive and pedagogically sound. This will most likely lead to more solid experiences, and will provide better results in terms of student learning. Those students, in turn, will be able to better apply the acquired knowledge and generate greater impact on country development, contributing to a greater acceptance of computing in K-12 Education.

V. Conclusions

In this work, we performed a systematic mapping study to understand how teaching and research initiatives on computational thinking and programming (CT&P) are being brought to Brazilian K-12 Education. To do so, we collected information on year, venue, type, K-12 Education stage and modality, methodological contexts, and used tools and programming languages. Results show a significant increase in the number of studies in the latest years in Brazil, describing a growing interest on this research area, and also point out to the trends and the existence of several research gaps to be addressed.

Future work must deal with additional research facets, such as CT skills, subject matter, assessment, curricular choices, pedagogical foundations, among others. We also intend to deepen the analysis by means of a systematic literature review of empirical work, where we plan to synthesize the scientific results gathered so far in Brazil.

REFERENCES

[1] J. M. Wing, "Computational thinking." *Communications of the ACM*, vol. 49, no. 3, pp. 33–35, 2006.

[2] V. Barr and C. Stephenson, "Bringing computational thinking to k-12: what is involved and what is the role of the computer science education community?" *Acm Inroads*, vol. 2, no. 1, pp. 48–54, 2011.

[3] C. S. T. A. CSTA and A. for Computing Machinery ACM, *CSTA K–12 COMPUTER SCIENCE STANDARDS*. Washington, DC: The National Academies Press, 2016.

[4] The College Board, *AP Computer Science Principles Course and Exam Description*. College Board, 2017. [Online]. Available: https://secure-media.collegeboard.org/digitalServices/pdf/ap/ap-computer-science-principles-course-and-exam-description.pdf

[5] O. Hazzan, J. Gal-Ezer, and L. Blum, "A model for high school computer science education: The four key elements that make it!" in *ACM SIGCSE Bulletin*, vol. 40, no. 1. ACM, 2008, pp. 281–285.

[6] Royal Society, "Shut down or restart? the way forward for computing in uk schools," *The Royal Society, London*, 2012.

[7] J. C. R. Pereira-Jr., C. E. Rapkiewicz, C. Delgado, and J. A. M. Xexeo, "Ensino de algoritmos e programação: uma experiência no nível médio," in *XIII Workshop de Educação em Computação (WEI'2005). São Leopoldo, RS, Brasil*, 2005.

[8] A. Bordini, C. M. O. Avila, Y. Weisshahn, M. M. da Cunha, S. A. da Costa Cavalheiro, L. Foss, M. S. Aguiar, and R. H. S. Reiser, "Computação na educação básica no brasil: o estado da arte," *Revista de Informática Teórica e Aplicada*, vol. 23, no. 2, pp. 210–238, 2016.

[9] SBC - Brazilian Computer Society, "Referenciais de Formação em Computação: Educação Básica," http://www.sbc.org.br/files/ComputacaoEducacaoBasica-versaofinal-julho2017.pdf, 2017.

[10] K. Petersen, R. Feldt, S. Mujtaba, and M. Mattsson, "Systematic mapping studies in software engineering." in *EASE*, vol. 8, 2008, pp. 68–77.

[11] B. Kitchenham, O. P. Brereton, D. Budgen, M. Turner, J. Bailey, and S. Linkman, "Systematic literature reviews in software engineering–a systematic literature review," *Information and software technology*, vol. 51, no. 1, pp. 7–15, 2009.

[12] R. S. de França and H. J. C. do Amaral, "Ensino de computaçao na educaçao básica no brasil: Um mapeamento sistemático," in *XXI Workshop sobre Educaç ao em Computaç ao*, 2013.

[13] A. L. Araujo, W. Andrade, and D. Guerrero, "Um mapeamento sistemático sobre a avaliação do pensamento computacional no brasil," in *Anais dos Workshops do Congresso Brasileiro de Informática na Educação*, vol. 5, no. 1, 2016, p. 1147.

[14] M. A. E. Matos and M. Osshiro, "Algoritmo: Mapeamento sistemático sobre o ensino de algoritmo para alunos do ensino médio," *South American Journal of Basic Education, Technical and Technological*, vol. 4, no. 1, 2017.

[15] L. Blatt, V. Becker, and A. Ferreira, "Mapeamento sistemático sobre metodologias e ferramentas de apoio para o ensino de programação." in *Anais do Workshop de Informática na Escola*, vol. 23, no. 1, 2017.

[16] L. F. de Paiva, P. Bompet, E. F. Corlett, E. Matos, and A. Schwarzelmuller, "A formação, o trabalho e a identidade profissional do professor de computação: um mapeamento sobre a licenciatura em computação," in *Anais dos Workshops do Congresso Brasileiro de Informática na Educação*, vol. 6, no. 1, 2017, p. 893.

[17] D. M. Nascimento, K. Cox, T. Almeida, W. Sampaio, R. A. Bittencourt, R. Souza, and C. Chavez, "Using open source projects in software engineering education: A systematic mapping study," in *Frontiers in Education Conference, 2013 IEEE*. IEEE, 2013, pp. 1837–1843.

[18] D. M. Nascimento, R. A. Bittencourt, and C. Chavez, "Open source projects in software engineering education: a mapping study," *Computer Science Education*, vol. 25, no. 1, pp. 67–114, 2015.

[19] T. P. Falcão, T. C. S. Gomes, and I. R. Albuquerque, "O Pensamento Computacional Através de Jogos Infantis: uma Análise de Elementos de Interação," in *Anais do XVI IHC - Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais - IHC.*, 2015.

[20] R. S. Rodrigues, W. L. Andrade, D. D. S. Guerrero, and L. M. R. S. Campos, "Análise dos efeitos do Pensamento Computacional nas habilidades de estudantes no ensino básico: um estudo sob a perspectiva da programação de computadores," in *Anais do XXVI SBIE - Simpósio Brasileiro de Informática na Educação*, 2015, pp. 121–130.

[21] A. B. Farias, W. L. Andrade, and R. A. Alencar, "Pensamento Computacional em Sala de Aula : Desafios , Possibilidades e a Formação Docente," in *Anais dos Workshops do IV CBIE - Congresso Brasileiro de Informática na Educação*, 2015, pp. 1226–1235.

[22] A. M. S. Silva, D. A. S. S. Moraes, and S. C. F. Batista, "Meio Ambiente e Sustentabilidade: ações pedagógicas no Ensino Fundamental com uso do Scratch," *Revista Eletrônica Tecnologias, Sociedade e Conhecimento - NIED/UNICAMP*, vol. 2, no. 1, pp. 63–84, 2014.

[23] J. B. Ortiz and A. Raabe, "Pensamento Computacional na Educação de Jovens e Adultos: Lições Aprendidas," in *Anais dos Workshops do V CBIE - Congresso Brasileiro de Informática na Educação*, 2016, pp. 1087–1096.

[24] L. F. D. Pereira, F. Lapolli, F. F. Sampaio, C. L. R. Motta, and C. E. T. Oliveira, "Ateliê de Objetos de Aprendizagem: Uma Abordagem para o Ensino de Computação em Cursos Técnicos," *Revista Brasileira de Informática na Educação - RBIE*, vol. 18, no. 3, pp. 4–18, 2010.

[25] M. Andrade, C. Silva, and T. Oliveira, "Desenvolvendo games e aprendendo matemática utilizando o Scratch," in *Anais do XII SBGames - Simpósio Brasileiro de Games e Entretenimento Digital*, 2013, pp. 260–263.

[26] T. S. C. da Silva and J. C. B. de Melo, "Cidade dos Bits: Um game para auxiliar no Aprendizado dos Fundamentos da Ciência da Computação a Nível Médio," in *Anais do XXIV SBIE - Simpósio Brasileiro de Informática na Educação*, 2013, pp. 915–919.

[27] D. O. da Silva, V. R. Garcia, I. G. de Oliveira, D. F. G. Trindade, E. M. Sgarbi, and L. F. L. Nascimento, "Despertando Jovens Talentos com o Conhecimento da Computação," in *Anais do XXII WIE - Workshop de Informática na Escola*, 2016, pp. 583–592.

[28] P. S. S. de Souza and J. G. Mombach, "Ensino de Programação para Crianças através de Práticas Colaborativas nas Escolas," in *Anais do XXII WIE - Workshop de Informática na Escola*, 2016, pp. 545–554.

[29] R. L. Queiroz, F. F. Sampaio, and M. P. dos Santos, "DuinoBlocks4Kids: Ensinando conceitos básicos de programação a crianças do Ensino Fundamental I por meio da Robótica Educacional," in *Anais dos Workshops do V CBIE - Congresso Brasileiro de Informática na Educação*, 2016, pp. 1169–1178.

[30] C. Schulte, M. Hornung, S. Sentance, V. Dagiene, T. Jevsikova, N. Thota, A. Eckerdal, and A.-K. Peters, "Computer science at school/cs teacher education: Koli working-group report on cs at school," in *Proceedings of the 12th Koli Calling International Conference on Computing Education Research*. ACM, 2012, pp. 29–38.

[31] A. L. S. O. de Araujo, W. L. Andrade, and D. D. S. Guerrero, "A systematic mapping study on assessing computational thinking abilities," in *Frontiers in education conference (FIE), 2016 IEEE*. IEEE, 2016, pp. 1–9.

[32] V. Garneli, M. N. Giannakos, and K. Chorianopoulos, "Computing education in k-12 schools: A review of the literature," in *Global Engineering Education Conference (EDUCON), 2015 IEEE*. IEEE, 2015, pp. 543–551.

[33] A. Farias, W. Andrade, and R. Alencar, "Pensamento computacional em sala de aula: Desafios, possibilidades e a formaçao docente," in *Anais dos Workshops do Congresso Brasileiro de Informática na Educação*, vol. 4, no. 1, 2015, p. 1226.