Computational thinking and TPACK in science education: a southern-Brazil experience

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Abstract

Numerous social, cultural and educational changes have been linked to the growing presence of ICT in human social activities and practices. We recognize, however, the need to have educational concepts and methodologies linked to technologies always allied to a strong theoretical and conceptual basis, in order to qualify the pedagogical process in basic and higher education. These elements support the creation of a center for the popularization of computational thinking and education (N2PCE) and actions related to university-school integration, with a view to qualifying students' education in these two contexts. The center also intends to assist education professionals in their pedagogical efforts, either in the field of computing, or in areas with specific knowledge in the fields of Mathematics and Physics. This paper illustrates experiences with basic education students, in activities closely associated with the field of science and technology, with computational thinking and the TPACK framework as theoretical and methodological support. Results suggest a significant redefinition of the fields of knowledge and potential intellectual, human and professional growth of the participants, as well as a possibility of popularization and demystification of the areas involved.

Keywords: ICT; computational thinking; TPACK; science education.

Pensamento computacional e TPACK na educação em ciências: uma experiência no sul do Brasil

Resumo

Inúmeras mudanças sociais, culturais e também na esfera educacional vêm sendo articuladas à presença crescente das TIC nas atividades e práticas sociais humanas. Percebemos, no entanto, a necessidade de termos concepções e metodologias educacionais ligadas às tecnologias sempre articuladas a um embasamento teórico e conceitual forte, de modo a qualificar o processo pedagógico na educação básica e superior. Esses elementos embasam a criação de um centro para popularização de pensamento computacional e educação (N2PCE) e ações ligadas à integração universidade-escola, com vistas a qualificar a formação de estudantes desses dois contextos, e também auxiliar profissionais da educação

em seus esforços pedagógicos, seja no âmbito da computação, como em áreas e conhecimentos específicos dos campos de Matemática e Física. Este artigo ilustra experiências realizadas com estudantes de educação básica, em atividades intimamente associadas ao campo de ciência e tecnologia, tendo o pensamento computacional e o framework TPACK como sustentação teórica e metodológica. Resultados sugerem uma significativa redefinição dos campos de conhecimento e potencial crescimento intelectual, humano e profissional dos participantes, bem como uma possibilidade de popularização e desmistificação das áreas envolvidas.
Palavras-chave: TIC; pensamento computacional; TPACK; ensino em ciências.

Pensamiento computacional y TPACK en la educación científica:
una experiencia en el sur de Brasil

Resumen

Numerosos cambios sociales, culturales y educativos se han relacionado con la creciente presencia de las TICs en las actividades y prácticas sociales humanas. Sin embargo, percibimos la necesidad de tener conceptos y metodologías educativas vinculados a tecnologías siempre vinculadas a una sólida base teórica y conceptual, a fin de calificar el proceso pedagógico en la educación básica y superior. Estos elementos apoyan la creación de un centro para la popularización del pensamiento computacional y la educación (N2PCE) y las acciones relacionadas con la integración universidad-escuela, con el fin de calificar la formación de los estudiantes en estos dos contextos, y también ayudar a los profesionales de la educación en sus esfuerzos pedagógicos, ya sea en el campo de la informática, como en áreas específicas y conocimiento en los campos de las matemáticas y la física. Este artículo ilustra las experiencias con estudiantes de educación básica, en actividades estrechamente relacionadas con el campo de la ciencia y la tecnología, con el pensamiento computacional y el marco TPACK como soporte teórico y metodológico. Los resultados sugieren una redefinición significativa de los campos de conocimiento y el potencial crecimiento intelectual, humano y profesional de los participantes, así como una posibilidad de popularización y desmitificación de las áreas involucradas.
Palabras clave: TIC; pensamiento computacional; TPACK; enseñanza de las ciencias.

Introduction

Technological innovation is one of the highlights that best characterize everyday life, and its effects have been felt in a generalized way in all sectors of human activity. Education is not immune to such effects; on the contrary, it is increasingly influenced by the “knowledge society” and has been constantly encouraged to implement strategies that strengthen the link between Science, Technology and Education. School itself has also been challenged to rethink its role as a locus of knowledge construction, which dialogues with initiatives that allow to provide everyone with a modern and updated education.

This process includes proposals for the constitution of individuals capable of adapting to rapid technological changes as well as able to understand, use and develop technologies in a critical, innovative and creative way. There are many discussions worldwide about the reformulation of national curricular guidelines with a view to introducing computational thinking in basic education (as well as in teacher education programs) as a way of expanding students' skills and competences (and their educators'), contemplating new paradigms in teaching and learning process.

Based on this context, we realize the need to deepen projects that are aligned with these issues, considering both Brazilian educational legislation[1] and the literature in this area, which point out the need to develop differentiated skills related to Information and Communication Technologies (ICT) with 21st century students. As ICT are human creations, they play a crucial role in enhancing students' thinking. They are not tools merely at the service of the population or teachers, but "intellectual partners" that help subjects to position themselves and act in the world, as stated by Jonassen (2000), and two decades ago (Kurtz, 2015).

Following this perspective, new cultural conditions require new cognitive skills (composed, in turn, by a range of skills that constitute them). In addition, it is necessary to be clear that, when the subject is to articulate teaching and technology, for many educators, the first movement is that of distancing, often linked to a technical and instrumental concern.

For many education professionals the theme itself becomes somewhat distanced from reflections articulated from theories and concepts that permeate and constitute the teaching profession itself, that is, there is a concern to reflect on aspects considered proper to "being a teacher of. .. ", but when it comes to the role attributed to ICT in education, the subject is restricted to the" domain of ... ", as if these instruments" orbited " around the pedagogical process, as Kurtz (2015) observes.

In this scenario, the popularization of science and technology through the dissemination of computational thinking is configured as an element of investigation, being the core of several initiatives at international level. Linked to this panorama, the Center for Popularization of Computational Thinking and Education (N2PCE) was developed to promote educational activities through the adoption of resources, tools and computational environments that explore the potential of strategies and that use computational thinking as a stimulus to curiosity, experimentation, collaboration and social interaction, problem solving and learning.

[1] National Common Curricular Base – known in Portuguese as "BNCC".

N2PCE's actions are supported by the assumptions of TPACK framework (Mishra and Koehler, 2006), which articulates content, pedagogical and technological knowledge in order to enable a training process that integrates knowledge demanded today. In line with this aspect, Jonassen highlights that cognitive tools are able to stimulate meaningful learning, “the construction of knowledge, reflective thinking, support new forms of thinking and reasoning and serve as instruments that help student think, as they are instances of reflection and representation of knowledge” (Jonassen, 2000).

The main purpose of this paper is to present actions conducted within the N2PCE, in order to articulate a theoretical scope around computational thinking and the TPACK framework to empirical investigation developed over the past three years in the context of the constitution of a digital culture in the school universe in partnership with the university. It was held mainly in the fields of Science and Technology, with specific domains in Mathematics.

We intend to contribute in expanding the potential for exchange of experiences and the confluence of knowledge between students, teachers and the school community towards the development of computational thinking, of educational activities promoted through the adoption of resources, tools and computing environments. The results presented and discussed explain activities that used computational thinking as a stimulus to curiosity, experimentation, collaboration and social interaction, problem solving and learning and, ultimately, strategies for popularizing and disseminating Science and Technology.

Literature Review: linking computational thinking and TPACK

The so-called “21st century skills” have contributed substantially to the realization of numerous reflections on education, at all levels, as well as on the pedagogical processes mediated by ICT. However, understanding about the role of these cultural instruments in the educational process is still a major challenge for teachers and students in Brazil.

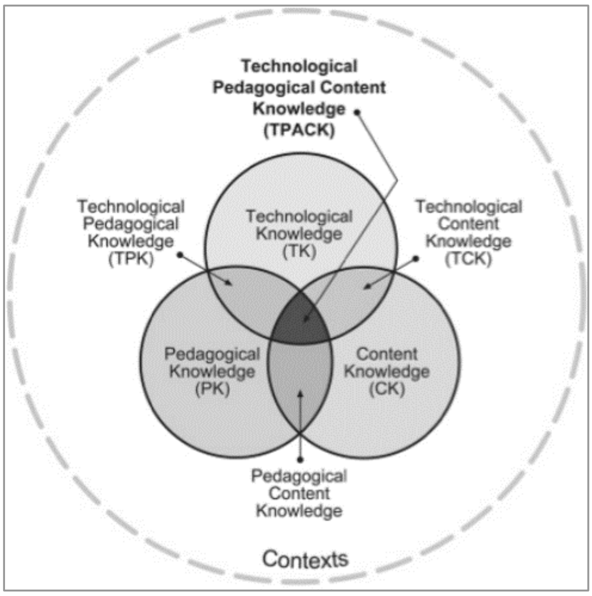
It is important to point out, from the Vygotskyan historical-cultural point of view (Vygotsky, 2008), that ICT are, in fact, cultural instruments that, once introduced into the flow of human activities, alter not only the subjects' social practices, but also their own biological functioning as pointed out by Wertsch (2002). According to these studies, it is quite common, in moments of behavioral transition, to introduce new forms of mediation or even the reworking of older forms, which, in turn, cause changes in the forms how subjects develop, consequently altering the flow and structure of mental functions.

As discussed in Kurtz (2015), ICT are, therefore, mediation tools and instruments. Tools, because it allows the construction of virtual objects, and mediation instrument, because |it allows the creation of new relationships for the construction of knowledge. But, for this, it is essential to keep in mind that technologies demand competences and skills that go beyond the performance of teachers as "teachers of...".

Among the numerous methodological proposals presented with a view to integrating technology in the classroom, one of the theoretical models recently investigated is the TPACK (Technological Pedagogical Content Knowledge), described by Shulman (1986) and developed by Punya Mishra and Matthew J. Koehler of Michigan State University in 2006. Still in a recent character in Brazil, it is a framework that describes knowledge needed by the teacher, regardless his/her field, considering that his/her attitude towards technology is multifaceted and results from the relationship between three types of knowledge: pedagogical, content and technological. Mishra and Koehler (2006) argue that this proposal, in the end, should serve as a basis for pedagogical processes and even for teacher education programs, in a spiral way, that is, starting the process with simpler technologies to which teachers are more familiar, followed by more elaborate applications.

The elements that make up the model can be explained, in a simple way, considering: a) content knowledge: refers to the object to be taught and learned, the contents developed in the classroom; b) pedagogical knowledge: on teaching and learning methodologies and methods, obviously encompassing in-depth theoretical concepts on the subject; and, c) technological knowledge: knowledge of certain technologies, as illustrated by Figure 1.

Figure 1: TPACK framework



Source: Mishra & Koehler (2006)

It is essential, based on these elements, to associate ICT to a new concept of competence, which, visibly, is no longer in the individual's realm, and becomes the group's activity, that is, it is a competence that transcends the constitution of the individual alone. It is a conception that articulates learning with competence, something quite complex, because in schools, and even undergraduate degrees (teacher education programs in Brazil as well), there is not always an alignment between competences actually worked and the knowledge proposed by institutional curricula.

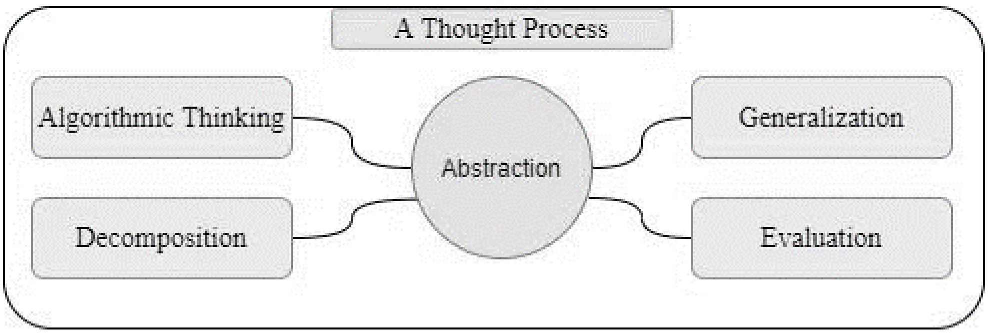
It is important to articulate in this context, Wing's watershed work (2006), “Computational Thinking”, in which she defends the idea that all people (children, youth and adults), in their educational formative processes, must consider and develop this way of thinking with the objective of constituting the knowledge and capabilities of Computer Science professionals. Wing (2006; 2010) states that cognitive resources present in computational thinking are transdisciplinary and universal and, therefore, can be useful to everyone.

More specifically, computational thinking consists of an approach to problem solving that explores concepts of computing. In this context, it considers a set of mental processes (mental tools) used by computer professionals when they operate with a view to solving problems through techniques, tools, practices and concepts of computing. In addition, Wing (2014) highlights something quite interesting, especially to subjects not directly involved with the computing area, stating that people can develop computational thinking without machines.

Considering these aspects, the development of computational thinking is not reduced to the use of technology, software, equipment, networks, etc., but corresponds to a structured way of reasoning used in problem solving, including recursive thinking, abstraction, automation, decomposition, modeling, simulation, among others (Bower et al, 2015). Although these principles are part of the essential capacities of computer scientists, many of them are equally essential for scientists / researchers in other areas, in a transversal way, with outstanding relevance to different subject profiles, since these capacities constitute a set of mental tools used in people's daily lives.

Within the scope of this paper, understandings about the contours of the computational thinking are anchored in the ideas and concepts presented by Wing (2006; 2010; 2014) and in the definition proposed by Selby (2013). To contribute to the discussions held by the academic community, Selby performed a literature review and, based on the most frequent terms, descriptions and meanings, proposed a definition of this thinking with a broad scope. Based on Selby's definition, Silva (2020) proposes a conceptual organization, in which he highlights the concept of abstraction as central in computational thinking (Figure 2).

Figure 2: Key concepts of Computational Thinking



Source: Silva (2020)

Briefly, these five key concepts can be understood as:

1) Algorithmic thinking, which considers the ability to define precisely and clearly the steps necessary to solve problems.

2) Evaluation, which includes the ability to evaluate processes in terms of efficiency and use of resources, as well as the ability to recognize and evaluate results.

3) Decomposition, understood as a way of thinking about problems, algorithms, resources, artifacts, processes and systems in terms of their parts. Analyzing the parts separately makes it easier to solve complex problems and design large-scale systems.

4) Generalization, as a cognitive process aimed at solving new problems based on similar solutions already established. This concept involves the ability to verify functional and structural characteristics common to different contexts and situations.

5) Abstraction, which refers to the ability to select attributes and hide the complexity and details of implementation in a problem solving process. Even though the act of abstracting is not exclusive to the area of computing, Wing (2006), defines particular characteristics that configure it as the central element of computational thinking.

In these terms, it is important to highlight that the use of ICT in Education is not something new. In order to conceive a teaching and learning process, in the contemporary technological context, one cannot ignore the need to rethink the process of mediation and interaction following the Vygotskian approach, and the educator's own role in such a context.

It is necessary to abandon a purely instrumental and technical teaching view with regard to ICT in the process of teaching and learning as tools in the service of the teacher, starting to be configured as an organizing and enhancing element of learning - as a cognitive tool -, in a perspective of learning "with" technologies, and not just "about" them. Educators must empower their students from this perspective in conjunction with the use of these resources so that, ultimately, they constitute skills and competencies that, integrated, make up computational thinking. In the following sections of this paper, we try to share some experiences in these terms.

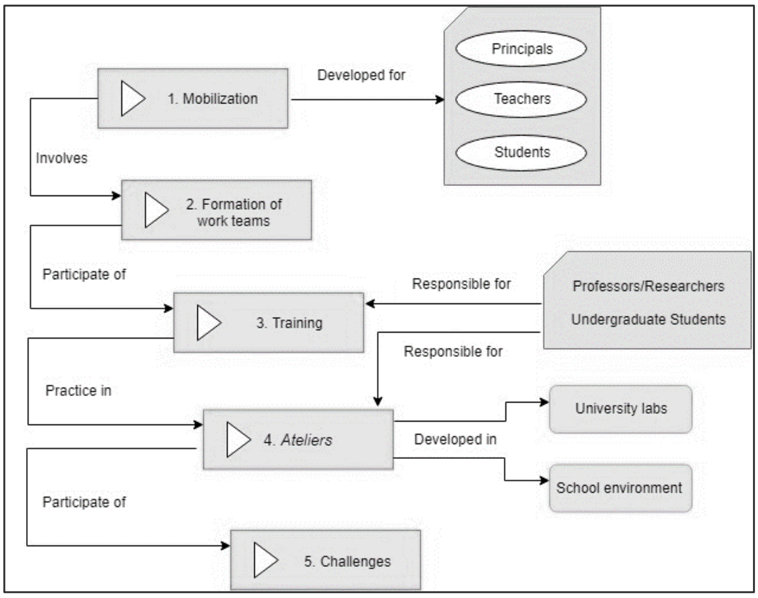
Methodology

We live in a society of networks and movements, a society of multiple learning opportunities, with enormous repercussions on the school institution, the role of the teacher and education in general. It is essential to learn to know how to communicate, to research, to know how to do, to have logical reasoning, to work collaboratively, to make syntheses and theoretical elaborations, how to organize one's own work, to have discipline, to be the subject of knowledge construction, being open to new learning, knowing the sources of information, knowing how to articulate knowledge with practice and with other knowledge.

In this context of information impregnation and "how to" learn, it is essential that schools and universities be actually partner institutions in order to conceive new spaces for training and human constitution, in their multiple dimensions. The student needs to be prepared to build and reconstruct knowledge from what he/she does, and the teacher, to assume a new role - that of articulator and mediator of the learning process.

This leads us to the definition of action strategies that are aligned to the promotion and constitution of a digital culture in the school universe, with actions being carried out in a perennial, systematic way and through a dialectical approach. Such strategies involve a methodology anchored in the assumptions of the TPACK framework that articulates content, pedagogical and technological knowledge. Figure 3 illustrates the adopted methodology for activities development, highlighting the activities developed, as well as the human resources and infrastructures involved.

Figure 3: Methodology developed for N2PCE's activities



Source: Ellaborated by the authors (2020)

The initial stage involves the "mobilization" of actions in school environments (principals, teachers and students). This mobilization takes on an important role, because, in addition to promoting dissemination, it also opens space for the university to provide the school universe with moments of discussion and reflection that can promote the attraction, knowledge, discovery and awareness of the importance of appropriating new skills. This strongly contributes to the rupture of stereotypes established throughout history, such as that the area of Mathematics (Hard Sciences) or even that Computing is an area isolated from the others, or even incompatible with certain groups, whether due to gender, economic condition, or other elements that have been – fortunately - deconstructed recently in society.

The second stage comprises the “formation of work teams”. A team generates positive synergy through integrated and coordinated effort, in addition to bringing together people with different visions and ideas that can promote beneficial results for everyone involved in the teaching and learning process. It is important to highlight that, according to the methodology adopted, the teams must be composed of high school students and at least one of their teachers.

As for the “training”, designated in stage 3, they comprise a theoretical-practical approach and are directly related to the elements of the TPACK framework as they involve knowledge of content encompassing theoretical concepts on the subject to be taught and learned, pedagogical knowledge on methodologies and teaching and learning methods and technological knowledge about the technologies to be used. As a way of contributing to a more effective appropriation of the content covered, a practical activity is proposed for each theoretical concept explored in order to demonstrate how the concept is applied. In addition, during the training sessions, we included activities to highlight the creative potential using brainstorming and pitch techniques to elucidate ideas. A pitch is characterized as a quick presentation of an idea / project, used to generate people's interest and attract the necessary resources to achieve it. Through this practice, the participants exercise the art of selling their ideas, improve their ability to communicate in public, and develop improvisation skills, essential for the question and answer moment, among others.

The workshops, in stage 4, are characterized as learning spaces guided by the maker culture and where resources, tools and computational environments should be used that explore the potential of strategies and that use computational thinking as a stimulus to curiosity, experimentation, collaboration, social interaction, problem solving and learning. The concept of “atelier” adopted in these initiatives is anchored in the epistemological conceptions about the learning process presented by Schön (2000), who states that reflective learning (reflection-in-action) happens when the centrality of the process is in the active participation of the student who, through practice, is constantly conditioned to reflect on his/her actions. In this perspective, there must be a process of constant interaction, dialogue and exchange of experiences, which, according to Schön (2000), is only possible in an environment that can be transformed into a studio, in analogy to a space that usually artists and artisans collaboratively work to produce their works of art.

The last stage of the methodology consists of promoting “challenges” with a view to opening a universe of opportunities to competitors, which go far beyond testing what has been learned in training and workshops, challenging other students and going in search of winning medals and awards. For young students, participation in challenges means an incentive to new horizons of studies and the discovery of fields of science and technology, and may even influence the choice of their professional trajectory. Participating in challenges is something stimulating for the young audience and provides opportunities for the development of socialization skills, the experience of different roles and the lessons learned from challenging situations. Still, another positive aspect is the fact that the participating students become multipliers of knowledge and enthusiasts of Education, that is, elements that propagate the idea that the path of education is always "rewarding".

In practice, the proposed methodology has been carried out in the last three years in projects whose focus is the development of computational thinking through different learning experiences (Santos, 2017a; 2017b; 2018). Next, we will share experiences that include the creation of applications, games and robotic devices that use these resources as cognitive tools with a focus on deconstructing the instrumental and technicist conception of mere "use" of technologies. We believe that this sharing of experiences presents itself as an important tool for other institutions to be able to replicate or improve them. We emphasize that, in all projects, the activities of stages 1 and 2 were carried out, involving the mobilization and formation of teams, respectively.

Mobile application development

Among the various initiatives that emerge in favor of the diffusion and dissemination of computational thinking, the development of mobile applications stands out. This focus is due, in part, to the growing interest of young people in the use of these technologies, and by the fact that the process inherent in the development of applications promotes the approximation of students with various principles of computational thinking.

Therefore, in the training stage, the concepts inherent to the software development process, human-computer interaction and programming logic were explored. We also seek to enable participants to get closer to the basics of smartphone operation by encouraging them to create apps of their choice for a device widely adopted by the general public. In addition, participants were familiarized with the MIT App Inventor 2 programming environment.

Based on the convergence of such content, we believe that production can take place efficiently, since it encompasses the various aspects related to application development. This environment presents itself as an innovative way of introducing programming and creating applications for beginners, transforming the complexity of programming languages. text-based programming for visual building blocks, lessening difficulties in the programming learning process and enabling the student to express properly in order to solve a problem without requiring a mastery of a specific language.

The use of environments that emphasize the formalization closer to natural language promotes greater facility to express a solution, without the need of a deep knowledge of syntax elaboration. The focus remains on solving the problem rather than worrying about syntactic language learning and frames learning situations in which students can realize the importance and applicability of the content they learn.

Thus, after students became familiar with the approach used in the APP Inventor environment, the potential of the environment was explored in practice during the workshop (ateliers). We direct efforts around programming practices, since programming permeates all areas of knowledge and guides the development of various cognitive skills of the student, to mention: creativity, logical reasoning, problem solving, criticality, reflection, interpretation, concentration, algorithmic and computational thinking, among others.

Following the methodology adopted, the last stage comprised the participation of the teams in a challenge that sought to foster the interest of young women in applying the knowledge obtained with a view to creating something that was socially useful and personally rewarding. For that, it was an intense three months of work in which the teams built a business plan, developed an application for a social problem and a pitch to present the idea. The competition's proposal was to “design an application aimed at improving people's quality of life”. Defining the scope comprehensively allowed students to explore a greater number of ideas and possibilities for solutions.

Among the application domains for which the applications were developed, we highlight four examples as illustrated in Figure 4: a daily schedule to assist caregivers for the elderly; best sale offers in the city's supermarkets; guidelines on the practice of physical exercises in outdoor gyms; and sustainable labels to assist selective garbage collection and the use of public transportation.

Figure 4: Examples of developed applications

Source: Ellaborated by the authors (2020)

The challenge culminated in an award and closing ceremony, where teams from the three best apps were awarded trophies and medals.

Game development

Digital games are potential strategies for the development of computational thinking, either because of the interactive and challenging proposal, or because of the possibility of working with the playful. Following this dimension, the approach through games in the teaching / structuring of computational thinking proves to be motivating and effective to what is proposed, as students exercise skills necessary for integral development, such as self-discipline, sociability, affectivity, moral values, team spirit and common sense.

These elements reiterate our understanding of the effectiveness of this approach, by driving the development of actions aimed at the development of games. In this scope, after carrying out mobilization and team building actions, training activities began which consisted of the following activities:

(a) contextualizing the area of games, relating it to the other areas of knowledge, in order to broaden the student's view of the constitution of the area;

(b) familiarization with the Construct 2 environment, which was chosen as a development tool, since it allows users with little or no previous experience with programming fundamentals to produce programs with reasonably sophisticated functionalities. For each theoretical concept addressed, a practical activity was developed in the tool in order to demonstrate how the concept is applied in the practice of implementing games;

(c) brainstorming and pitch workshops, aimed at promoting spaces to encourage participants to arouse opinions, share ideas and develop the possibilities for solutions, thus expanding their creative capacity.

After the activities related to training have been completed, games development workshops have been promoted, which consist of essentially practical activities. During the workshops, concepts such as sprite animation, collision, keyboard and mouse controls were explored; programming fundamentals such as variables, conditional structures, loops and messages; human-computer interaction and gameplay heuristics. University laboratories are an important space, as they promote learning experiences that bring participants closer to basic principles of computational thinking such as problem solving, abstraction, decomposition, among others, related to the design and conception of digital games.

Once the participants appropriated the concepts and tools necessary for the development of games, the students were removed from the comfort zone and challenged to develop a game aimed at the educational area. Despite limiting the area of knowledge for which the application would be developed, the defined scope was broad enough to allow participants to use creativity in defining the application/game. The use of brainstorming and pitch techniques for generating and presenting ideas were encouraged.

The games developed included application domains such as Mathematics teaching; guidance on the practice of physical exercises in outdoor gyms; blood donation and organ donation; garbage collection, among others.

Free Educational Robotics

Free Educational Robotics can be considered a mediating tool in the learning process, valuing planning, research, interest, motivation and cooperation among students, through a rich interdisciplinary experience, since it involves different areas of knowledge and people in solving problems; in addition to free solutions to replace commercial products.

In addition, it is in line with the concepts defended by the Brazilian Computer Society (SBC, 2019), considering that the teaching of robotics must start in schools, in elementary and high school, advancing to adulthood. As Osório (2017) states, these activities stimulate the approach of new generations to new technologies, demystification of robotics, creativity, development of a greater critical capacity, logical reasoning, solving practical problems, questioning solutions, and acting in multidisciplinary and interdisciplinary areas.

For each participating team, a robotic kit, called Sumo Arduino UR20 Robot, was made available by the N2PCE, which presents all the necessary parts for the construction of the base chassis, as well as sensors for object detection, sphere-type front wheel, engines with reduction box, in addition to rubberized wheels for displacement. Also included in the kits are 2 fairings printed in 3D that can be used to customize the robots, both in terms of aesthetics, functionality and protection of other parts.

The initial activity of each team consisted of assembling the robot. To assist this activity, instructional videos and an illustrated manual were prepared and made available highlighting the step-by-step of the assembly. It is important to note that, in case of doubts or difficulties in the activity of assembling the robot, the teams were able to count on the help of academics from the Computer Science and Information Systems courses that are part of the project's executing team. Once the robot assembly stage is over, programming workshops have started, in which the knowledge of programming, electronics and digital systems are used for the manufacture and programming of robots.

For the execution of the workshops and programming workshops, we opted for the adoption of an active teaching methodology. To this end, we use as a pedagogical resource a series of instructional materials in the form of videos, communication channels and discussion forum. From this, the activities related to the robot's programming could be developed respecting the learning time of each team, as well as their availability of schedules adaptable to the reverse class shift. In addition, upon demand from the teams, face-to-face appointments were scheduled at the University's robotics laboratory, in which doubts were resolved by each of the participating teams. It should also be noted that the face-to-face meetings were also used to carry out tests and adjustments in the robots' programming.

Figure 5: Face-to-face meetings with free robotics teams and robotics competition

Source: Ellaborated by the authors (2020)

The project's actions culminated in the participation of teams from all schools in a Competition held at the University, as illustrated in Figure 5. The competition, in the "Sumo" format, consists of the presence of two robots in a small circular arena performing actions that were programmed and loaded into the robots by the competitors, in order to remain within the arena for a specified time. Robot Sumo can be seen as a typical challenge for an autonomous exploration robot that has, as a course limit, a circular platform limited laterally and whose task is the removal of its opponent who has the same objective.

In this sense, we understand the project and study conducted brought up a collective construction, based on respect and openness to dialogue, establishing a more fruitful and lasting link with schools, at the same time that it provoked a more effective performance and participation of basic education teachers, mostly in Mathematics and Sciences fields. Students could understand the “new technological instruments” and their potential to solve society's problems, in addition to considering the area of Mathematics, Sciences and Computing, in their breadth of possibilities, as a choice for a professional future.

Results and discussion

Reflections on the practices presented in this text try to align with the current strategies of dissemination of computational thinking, following a transformation movement based on the logic of knowing, learning and transforming. The joint efforts focused on the challenge of exchanging experiences and the confluence of knowledge between students, teachers and the school community.

In this sense, the experiences reported in this text are, of course, subject to different analyzes. When articulating the concepts considered basic that both supported and emerged with other senses, the experiences carried out in a collaborative way between university and school. Indeed, assuming ICT and computational thinking as theoretical and methodological dimensions inherent to the training process of basic education students (and, consequently, future teachers in undergraduate courses) seems, indeed, to be one of the main results verified from the study we've been doing.

From these sets of experiences, it was possible to perceive how certain concepts can even guide the realization of specific activities in the core of which are actions once regarded only to the area of Computer Science, but which are effectively, fundamental to the subjects that interact in a historical-cultural context permeated and altered by ICT.

Thus, despite the quantitative aspect not being configured as a central element, we consider it important to situate the universe of subjects involved in the initiatives carried out. In all, 17 schools from 9 cities were served in the last 3 years experienced, involving the participation of 562 students and 89 teachers.

Chart 1 presents a compilation of the actions developed, contemplating, for each of them, the concepts articulated to computational thinking that were most explored.

Chart 1: Actions developed and concepts addressed

Activities	**Computational Thinking concepts developed**
1. Applications development	Abstraction Decomposition Generalization
2. Games developmet	Abstraction Algorithmic Thinking Decomposition Generalization
3. Free Educational Robotics	Abstraction Algorithmic Thinking Evaluation

Source: Ellaborated by the authors (2020)

From the data presented in Chart 1, we can verify contributions promoted in different contexts and in different scenarios. On the one hand, it was possible to approach a relatively expressive number of students in the field of computing, contributing to minimize the belief in the stereotype that the field of computing is difficult, which can often lead young people away from their professional careers. Through the actions promoted, it is possible to establish a gradual process of popularization, awareness, reflection and demystification with regard to the senses and meanings of computational thinking for the development of important skills for the education of students, which further enhances the intimate association of innovation processes, also in Education.

On the other hand, we are supporting the conceptions of teacher education for the systematization of experiences and the production of knowledge. An important point to be highlighted is that, although teachers find, in the technological and methodological resources adopted, ways to work and develop content in the classroom, they still feel unprepared to develop activities without the help of university professors. Many seek university support for the development of activities aimed at the use of technological resources in the school environment, as they understand the importance of this resource in the training of students, but do not have enough knowledge to develop activities in this area on their own. This dimension, certainly, needs to be enhanced, in order to strengthen the partnership role between university and school, and not that the school serves as a "receptacle" for the discoveries and actions proposed by the university.

Still, regarding the school context, it is important to highlight that, in addition to the new skills, competences and roles of the agents that make up the scenario of the educational institution, it is also important to highlight the social and democratic paradox that plagues the Brazilian scenario with regard to the new stance of educational institutions, where the concept of school is seen as a prime instance of democratization for the establishment of full citizenship. Although it is not the only one, it is certainly one of the necessary and contingent factors for the construction of an egalitarian and just society.

This concern runs through, at the university level, the commitment to promote universal access to cultural goods produced by humanity, creating conditions for learning and the development of all, reducing inequalities and contributing to the expansion of the subjects' cultural and scientific repertoire.

Perhaps the most important results obtained so far are the changes in the view of teachers, schools and students regarding the area of information technology. In line with this, there is the enrichment of learning spaces made available by schools and the alteration of curricular matrices in some schools, mainly public ones. It is already becoming a reality, for example, the insertion of curricular components aimed at the use of educational robotics as a means of enhancing the teaching and learning of contents in subjects such as Physics and Mathematics.

According to the pedagogical supervisor of a partner school, "*the idea is that robotics is a means of linking disciplines, allowing not only Physics, but also other areas of knowledge to have a current approach, thus confirming the commitment that the school has the full education of the student*". As the principal of this same school, "*the proposal is that robotics as a component, be in the curriculum matrix of 2020, allowing an interdisciplinary integration, in which the student can develop his skills and competences to the full*".

Aligning his efforts with initiatives verified at national and international level, the principal also stresses that "*by learning and practicing the whole process that leads to* *scientific production, our student, who already has a proactive profile, can make a difference in the community. This is the student that we want and that society expects*".

Current and future generations need the new. Decontextualized practices or that incorporate elements called "new", but as transpositions of the "old", without a qualified process of conceptual and epistemological significance, discourages an audience that has easy access to so much information, but that lacks the school and the teacher to elevate this information to another level of abstraction.

Some final remarks of our study consider that the university is committed to the construction of a "pluriversal" world, as one of the expressions to generate and disseminate knowledge in order to contribute effectively to broaden the horizon of understanding of the subjects. In short, changes are possible, from the moment we prepare for them. When we provide students and teachers with contact with reality, we open space for reflection based on action and offer opportunities for future professionals to contact reality beyond the theoretical universe.

In order for Brazil to be a protagonist on the world stage and its population to reach better levels of quality of life, reducing social and economic inequalities, the path is through Education, development of creative and innovative capacity. In the 21st century, Computing is fundamental in this process and that is why basic principles in this area, in a deep dialogue with scientific principles in the fields of Mathematics, Physics, Languages, among others, are disseminated to all students of Basic Education, both in Elementary and Secondary Education as well as teacher education programs. These areas demand – and deserve – serious investments.

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