


## The protagonism of K-12 students through the development of smartphone applications


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### Abstract

The importance of learning computational thinking in K-12 is well recognized today. Computational thinking encompasses problem solving as well as knowledge of algorithms and programming, which can be taught through the development of mobile applications. Using a visual block programming language such as App Inventor, middle school students can learn to develop functional applications for smartphones, allowing them to understand and apply concepts of computing, interface design among other skills. Adopting computational action as pedagogical strategy allows to resolve problems in the local community, as part of computing education. In this context, the article presents a case study evaluating the learning experience of the students participating in the project "Young Programming Tutors", through the pedagogic practice "Make your first app", created by the initiative Computação na Escola/INCoD/INE/UFSC in 2018, which aims to teach computational thinking to middle school students through the development of applications. In addition, the students collaborate by teaching computing and knowledge and programming competencies to other students at their school. The results of this case study show that this pedagogical practice can contribute to the interest and motivation of the students, covering subjects with respect to their lives and community. Such perspectives tend to strengthen the construction of knowledge and the development of student skills, encouraging construction rather than just the consumption of technology.

**Keywords:** Computational thinking. Mobile application. Middle school.

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**Resumo****O protagonismo de estudantes da Educação Básica a partir do desenvolvimento de aplicativos para *smartphone***

A importância da aprendizagem do pensamento computacional já é discutida na Educação Básica. O pensamento computacional engloba a resolução de problemas, além de outras habilidades, conhecimento de algoritmos e programação, o que pode ser ensinado por meio do desenvolvimento de aplicativos móveis. Utilizando uma linguagem de programação visual, como *App Inventor*, estudantes da Educação Básica podem desenvolver aplicativos funcionais para *smartphones*, possibilitando a eles o aprendizado de conceitos de computação, de *design* de interface, entre outras habilidades. É adotada como estratégia metodológica a ação computacional, uma abordagem que visa ensinar computação por meio da resolução de problemas na comunidade local. O artigo apresenta um estudo de caso avaliando a experiência de aprendizagem de estudantes no projeto 'Jovens Tutores de Programação', a partir da prática pedagógica 'Faça seu primeiro app', criada pela Iniciativa Computação na Escola/INCoD/INE/UFSC em 2018, que visa ensinar pensamento computacional a jovens do Ensino Fundamental por meio do desenvolvimento de aplicativos. Além disso, os jovens colaboram ensinando o conhecimento de computação para outros alunos do Ensino Fundamental. Os resultados deste estudo de caso mostram que essa prática pedagógica pode contribuir para o interesse e a motivação dos estudantes, abrangendo temáticas com base na vida deles e da comunidade, e com isso oportunizando o protagonismo dos estudantes. Tais perspectivas tendem a fortalecer a construção do conhecimento e do desenvolvimento de habilidades dos estudantes, incentivando a construção, ao invés de apenas consumo de tecnologia.

**Palavras-chave:**

Pensamento computacional.  
Aplicativo móvel.  
Ensino fundamental.

**Resumen****El protagonismo de estudiantes de la Enseñanza Básica a partir del desarrollo de aplicaciones para *smartphone***

La importancia de aprender el pensamiento computacional ya se discute en Enseñanza Básica. El pensamiento computacional abarca la resolución de problemas, así como otras habilidades, el conocimiento de algoritmos y la programación que se pueden enseñar a través del desarrollo de aplicaciones móviles. Usando un lenguaje de programación visual como *App Inventor*, los estudiantes de Enseñanza Básica pueden desarrollar aplicaciones funcionales para teléfonos inteligentes, permitiéndoles aprender conceptos de computación, diseño de interfaces y otras habilidades. Se adopta como acción computacional de estrategia metodológica, un enfoque que apunta a enseñar computación resolviendo problemas en la comunidad local. El artículo presenta un caso de estudio que evalúa la experiencia de aprendizaje de los estudiantes en el proyecto "Jóvenes tutores de la programación", basado en la práctica pedagógica "Haga su primera aplicación", creado por Initiative Computação na Escola/INCoD/INE/UFSC en 2018, que tiene como objetivo enseñar el pensamiento computacional a los jóvenes en la escuela primaria a través del desarrollo de aplicaciones. Además, los jóvenes colaboran en la enseñanza de la alfabetización informática a otros estudiantes de escuela primaria. Los resultados de este estudio de caso muestran que esta práctica pedagógica puede contribuir al interés y la motivación de los estudiantes, cubriendo temas basados en su vida y la comunidad, y proporcionando así el protagonismo de los estudiantes. Tales perspectivas tienden a fortalecer la construcción de conocimiento y el desarrollo de las habilidades de los estudiantes, alentando la construcción en lugar de solo el consumo de tecnología.

**Palabras clave:**

Pensamiento computacional.  
Aplicación móvil.  
Educación primaria.

## Introduction

The integration of digital information and communication technologies in learning and a school environment is currently one of the great challenges of education. They represent the knowledge of new skills from multi-courses, which requires greater familiarity of students and teachers with digital resources (ALMEIDA and VALENTE, 2011). Among the possible ways to achieve this, the authors point out the need for practices focused on logical and computational thinking, emphasizing that it is necessary to rescue the term “computational thinking”, a relatively recent discussion, even though the concept itself has already been pointed out earlier by Papert, creator of the Logo<sup>1</sup> programming language.

Computational thinking, defined by Wing (2006), encompasses a problem-solving approach aggregating a set of concepts and has been seen as a fundamental skill in the 21st century. This is due to its focus on worldwide demands for education in the digital age (PÉREZ GÓMEZ, 2015), including cognitive abilities derived from computer science (RESNICK et al., 2009; GROVER AND PEA, 2013; KAFAI AND BURKE, 2013). According to Almeida and Valente (2019) Wing's proposal (2006) regarding computational thinking.

aroused the interest of several countries in rethinking their policies and the use of digital information and communication technologies in education, and in guiding teachers to carry out practices that emphasize the exploration of the concept of programming with a focus on the development of logical and computational thinking (ALMEIDA and VALENTE, 2019, p.207).

For developing computational thinking with K-12 students, there is typically a focus on teaching algorithms and programming, using block-based visual programming environments such as Blockly (Blockly, 2019), Scratch (Scratch, 2019) or App Inventor (MIT, 2019). These environments provide an intuitive interface and allow the fitting of a piece by matching code with the correct syntax (VALENTE, 2016). In this context, the App Inventor programming environment, for example, allows the programming of fully functional mobile applications for smartphones and tablets addressing programming concepts such as conditionals, events, variables, among others as well as the design of the user interface.

Researches in this field are based on the foundation that the teaching of computational thinking, programming and design can contribute to the education of the 21st-century student, preparing him/her to deal with the challenges of the digital age (PÉREZ GÓMEZ, 2015), including problem-solving connected to real-world issues, based on computational action (WANG, 2015; TISSENBAUM et al., 2019).

By connecting with the students' real life, we can help them develop a critical awareness of the role they can play in affecting their community through computing and enable them to go beyond simply learning to code. Instead, we can ask them what they want to code and why they want to code it (TISSENBAUM et al., p.36, 2019).

This process can occur through the development of mobile applications in programming environments, such as App Inventor, which with more than 400,000 active users currently present in 195 countries, has enabled the creation of almost 22 million applications (MIT, 2019) and, for this reason, it has been used quite successfully in different initiatives in school settings.

Thus, starting from the questions encompassing the teaching of computational thinking, focused on algorithms and programming, the pedagogical practice “Make your first app” was planned within the Young Programming Tutors project, developed systematically following the instructional design model ADDIE (BRANCH, 2009). The pedagogical practice, which we will present in more detail, was applied and evaluated in a case study developed with K9 students from a municipal public school in Florianópolis/Santa Catarina/Brazil.

### Application of pedagogical practice

The Young Programming Tutors project was applied at the Municipal Basic School Almirante Carvalhal, located in the continental region of Florianópolis/Santa Catarina/Brazil in the second semester of 2018. The project involved 10 Young Tutors selected by the school staff, 5 girls and 5 boys, students from K8 and K9 of the school and aged between 13 and 15 years.

For the application of this project, in addition to the Computing at School team, it also involved information technology professionals and K-12 teachers, who joined a multidisciplinary team to help young tutors with respect to two challenges: to develop their first app and to collaborate with other K9 students, teaching what they learned about computing and programming.

To achieve the objectives of the first challenge, developing a mobile application, 12 meetings were held, following a syllabus as shown in Table 1.

**Table 1** - Meetings of the Young Programming Tutors Project

Meeting	Place
Training with participants (Young Tutors, technology and school staff)	UFSC
Motivation and basic concepts of computing and application development; Basic computing concepts: algorithm/programming	School
App development process and problem/solution identification	School
Context analysis and requirements specification	School
Low-fidelity prototype and testing	School

Programming and testing of the prototype in App Inventor (2 meetings)	School
Creation and testing of visual design in App Inventor	School
System testing	School
Sharing the app	School
Preparation for the presentation of the app	School
Presentation of apps developed by students	<i>Involves Company, project partner</i>

Source: prepared by the authors.

The meetings took place during extracurricular school hours, covering the development of the app itself and other activities corresponding to learning how to teach computing. The meetings made it possible to learn how to develop a functional application, based on the students' ideas, within the broad challenge of “solving society's problems”, proposed by the team.

The first of these meetings was held at the Federal University of Santa Catarina (UFSC), an opportunity in which the students, Young Tutors, participated in a training carried out by the *Iniciativa Computação na Escola* team together with the information technology professionals of the project's sponsoring company. During this meeting, students learned basic concepts of algorithms and programming and learned about the App Inventor environment, programming a first predefined application, which served as a reference for the subsequent development of their apps, adopting agile design thinking practices.

To assist in the second challenge, sharing their learning, the Young Tutors participated in the realization of 3 programming workshops, contributing to their understanding of the process of giving workshops, an activity that they had to apply with other students of the school. Figure 1 presents some of these moments.

**Figure 1** – Applied workshops with school students



Source: private collection of authors.

During these workshops, the Young Tutors taught concepts of algorithms using also the unplugged game SplashCode (GRESSE VON WANGENHEIM et al., 2019) and taught the programming of a simple application with App Inventor. In total 51 students, aged 10 to 14 years, participated in the workshops.

To finalize the project, the Young Tutors presented their apps at the project's partner company, as shown in Figure 2. They showed the ideas developed during the execution of the project, indicating the reasons for their choices, explaining the problem involving a community concern and the developed solution, in addition to the computer learning, visual design, and software engineering aspects that were approached during the project.

**Figure 2** – Presentation of Young Tutors at the technology partner company

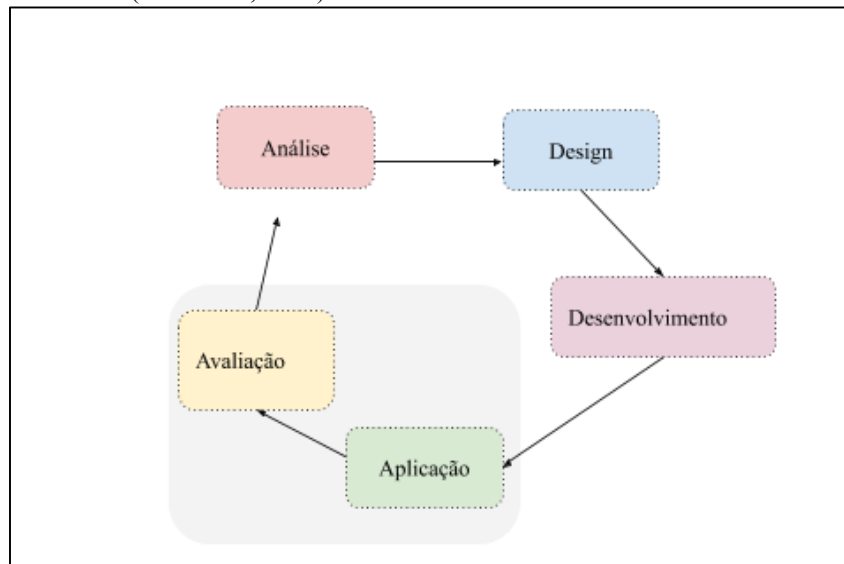


Source: private collection of authors.

## Research Methodology

In this exploratory research, a multi-method methodology was adopted. According to Gil "the main purpose of exploratory research is to develop, clarify and modify concepts and ideas, to formulate more precise problems or researchable hypotheses for further studies" (GIL, 2008, p.27).

The pedagogical practice was developed following the instructional design model ADDIE (BRANCH, 2009) (Figure 3). During the first stage, the context was analyzed in terms of the students' profile as well as the school context. During the design stage, the learning objectives and the instructional/pedagogical strategy documented in the syllabus were defined. In the development stage, instructional material was created using the App Inventor programming environment.

**Figure 3** - Adapted ADDIE model (BRANCH, 2009)

For the application and evaluation of the pedagogical practice, an exploratory case study was carried out following (WOHLIN et al., 2012; YIN, 2017), aiming at evaluating the learning experience of the students participating in the project “Young Program Tutors”. The evaluation of the case study was systematically defined, executed, and analyzed. During execution, data were collected through questionnaires, and the collected data were analyzed using descriptive analysis techniques.

### Development of the pedagogical practice “Make your first app”

#### Context analysis

The target audience of this pedagogical practice is K9 students between 10 and 15 years old. They have access to desktop computers in schools, use mobile devices such as smartphones, and use in the school space is restricted to educational purposes.

There are laws in some Brazilian states that, despite prohibiting the use of cell phones at school, allow their use for educational purposes. The number of non-uses is significant, which may be linked to other issues involving infrastructure, but it can also be a reflection of outdated, poorly innovative pedagogical practices (MEDEIROS, 2019, p.31).

Within the school environment, this access takes place in computer labs, which are equipped with desktop computers and Internet access, where educational technology classes take place and where pedagogical practices are applied, integrating digital media with curricular content, such as didactic resources with the use of educational sites and computer programs. The activities developed do not specifically include the teaching of computing, since this knowledge area is currently not part of the Brazilian curriculum of K-12. However, in some cases, such practices are introduced in these environments during extracurricular school hours, through projects.

Thus, through the teaching of computing in K-12, we aim to develop computational thinking inserted in a pedagogical practice, through the development of the programming of a mobile application, following the curricular guidelines for computer education in K-12 (CSTA, 2017; SBC, 2018).

### Defining learning objectives

The pedagogical practice "Make your first app" aims to teach computational thinking focusing on algorithms and programming taking into account the context. Thus, the teaching of algorithms and programming is addressed as a main part of computing. Software engineering and usability concepts are also addressed, being important fields for software development. The learning objectives are presented in Table 2.

**Table 2** – Learning objectives

ID	Learning objective
LO1	Understand algorithms as a set of step-by-step instructions for performing tasks.
LO2	Explain the concept of a software life cycle and provide an example, illustrating its phases, including the deliverables that are produced.
LO3	Develop iteratively computational artifacts collaboratively, following a schedule.
LO4	Identify and solve problems by creating interactive software systems.
LO5	Analyze the context of interactive software systems in terms of users, tasks, devices, and usage environments.
LO6	Specify requirements for interactive software systems in terms of functionality and usability.
LO7	Create prototypes of interactive software systems at different levels (sketches, low fidelity, high fidelity, functional).
LO8	Design solutions that combine hardware and software components to collect and exchange data (sensors, APIs, etc.).
LO9	Model processes by creating and following navigation maps/algorithms to complete tasks.
LO10	Use flowcharts, pseudocode and/or navigation maps to solve complex problems.
LO11	Create the visual design (colors, typography, icons, images, etc.) of the software system interactive.
LO12	Build interactive software systems that include sequencing, events, conditionals, variables, lists, and strings using a block-based visual programming language.
LO13	Seek and incorporate feedback from team members and users to refine a solution that meets the user's needs.
LO14	Test and refine an interactive software system for functionality and usability.
LO15	Recommend improvements in the design of computing devices based on the results of verification and validation.
LO16	Share the developed interactive software system.

Source: prepared by the authors.

### Definition of the pedagogical strategy

The pedagogical practice was applied in 12 weekly meetings, each lasting approximately 3 hours, in addition to the use of asynchronous activities via the Moodle platform. It was interesting for participants



to have meetings inside and outside the school, enabling an expansion in the understanding of other educational learning environments. This includes meetings at the Federal University of Santa Catarina (UFSC) and the partner company, generating curiosity about them and their areas of expertise, contributing to the students' life and experience.

To provide students with a motivating learning experience, computational action is used as a pedagogical approach, a proposal that seeks the solution of technologies that have a social impact on students' lives (TISSENBAUM et al., 2019). Several instructional methods are adopted, emphasizing the practical application of the concepts covered with practical mobile application development activities:

- Direct instruction: presentation of content and information by teachers presenting the content step by step and using examples.
- Indirect instruction: students have greater autonomy, based on decision making and problem-solving. The teacher is a facilitator, who mediates the learning process, giving feedback to students.
- Interactive instruction: group dynamics structure, which allows exchanges between teachers, students, and colleagues participating in the activity.
- Experimental learning: both inside and outside the classroom. Nowadays it is possible to indicate the contact via moodle and by applications.
- Independent studies: encourages students to plan and put into practice the learning developed in the preparation part for presenting the results.

The pedagogical strategies applied in this project were defined based on the learning objectives previously determined by the multidisciplinary team. Among them is the understanding of the concept of algorithms in a playful way through the unplugged board game SplashCode (GRESSE VON WANGENHEIM et al., 2019) as well as complementary activities through homework, holding programming workshops with other classes at school, sharing the knowledge learned by the Young Tutors and socializing the applications developed by the students themselves. Figure 4, illustrates the result of some of these activities.

**Figure 4** - Examples of teaching materials developed



SplashCode Educacional Game



Slides



Tutorials



homework in moodle environment

Source: Pinheiro, (2019), Missfeldt Filho (2019) e Wangenheim *et al.* (2019).

Figure 5 - Apps developed by Young Tutors during the project<sup>2</sup>

Developed Apps	Presentation Slides
<p><i>Achei o seu Emprego</i></p>	 <p>Auxilia a encontrar o seu emprego. Permite o cadastro de vagas pelas empresas e também a busca por empregos.</p>
<p><i>AppPhone</i></p>	 <p>Ajuda a encontrar telefones úteis, especialmente em momentos de emergência.</p>
<p><i>Floripa Praias</i></p>	 <p>Exibe informações sobre praias de Florianópolis como balneabilidade, acesso e trilhas.</p>



Source: prepared by the authors.

## Evaluation of the pedagogical practice

The purpose of this case study is to evaluate the students' learning experience in the Young Programming Tutors project. We aim to understand the interests and motivations for learning in the school context, also considering significant learning, which "is a learning process in which we can assign meaning to the content learned" (ZABALA, 2002, p.97). Zabala also stresses that without understanding the meaning, it cannot be said that a concept or principle has been learned.

### Definition of the evaluation

The evaluation is defined by adopting the Goal/Question/Metric (GQM) approach (BASILI et al., 1994), decomposing the research question into measures, and guiding the development of data collection instruments.

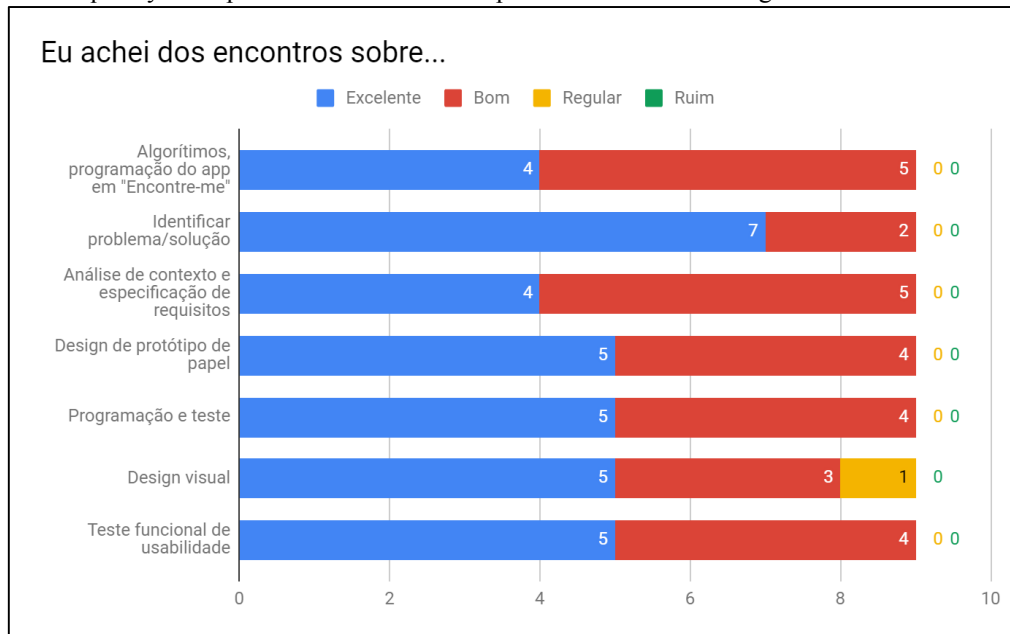
Here we aim at responding to the following **research question**: pedagogical practices for teaching computing through the development of mobile applications contribute to the interest and motivation of students in the school context?

In order to analyze this question, we conducted a qualitative and quantitative study on the level of reaction and learning according to Kirkpatrick's model (2006). Data were collected through questionnaires from students, information technology professionals from the project partner company, and school teachers, in addition to observations and evaluation of the students' projects.

### Research data

Regarding the students' experience as a participant in the Young Programming Tutors project, they demonstrated through the responses in the questionnaires, that they perceived the project as a positive experience, as shown in Figure 6, basically evaluating all criteria as excellent or good.

**Figure 6** - Frequency of responses from 9 students' opinions about the meetings

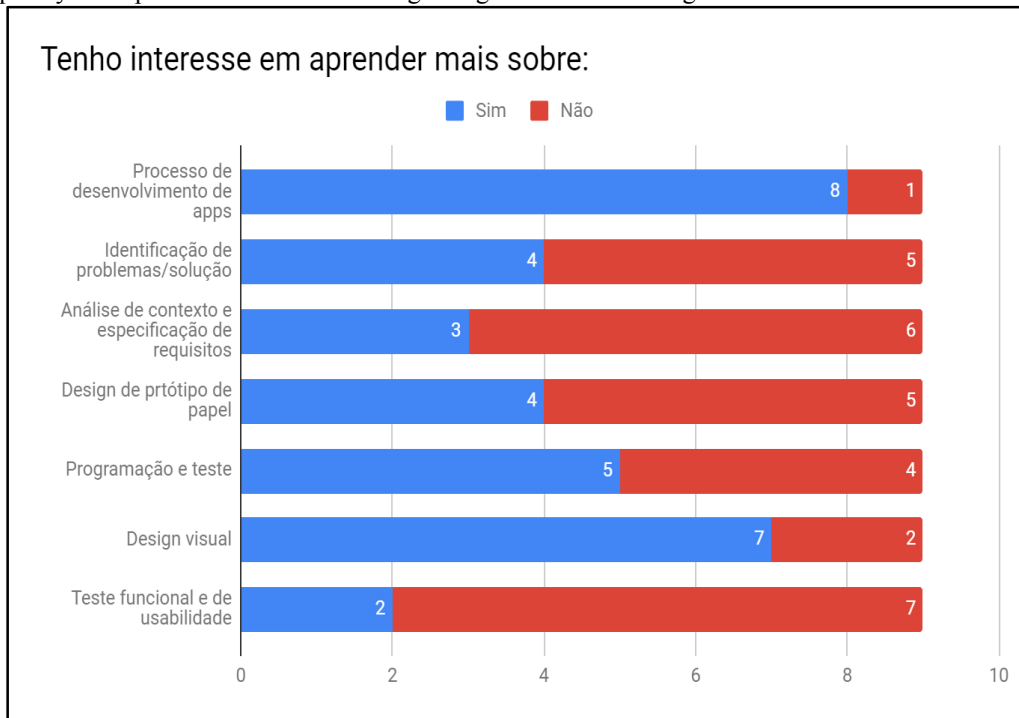


Source: prepared by the authors.

The meeting on the identification of the problem/solution, which encompasses the apps development process, through the topics chosen by the students, stands out with the highest number of responses considering this meeting as excellent. It can be inferred that the development of an application concerning the students' interest is a very significant factor for their motivation, as also indicated by the literature in the area.

To obtain the students interest, it is necessary that the objectives of knowing, carrying out, informing, and deepening are a consequence of identified interests; that they can always know what is intended in the activities they perform and that they feel that what they do satisfies some need. Therefore, it is essential for these boys and girls to have the opportunity to express their ideas and, based on them, to enhance the conditions that allow them to thoroughly review these ideas and expand their experiences with new ones, making them aware, also of their limitations, placing them in a position to modify them if necessary, while looking for other alternatives (ZABALA, 1998, p.94).

When asked what they are interested in learning more about (Figure 7), the students cited mostly application development and visual design processes.

**Figure 7** - Frequency of responses from 9 students regarding interest in learning more

Source: prepared by the authors.

On the other hand, the students showed much less interest with respect to testing, which can be exhausting due to the repetition of actions and also the infrastructure.

Table 3 presents the comments of a simple descriptive self-assessment of what they liked and disliked the most about the mobile application they developed during the project.

**Table 3** -What did you like most/least?

What did you liked most developing the app?	What did you liked least like developing the app?
Visual design, color palette and tals (4)	Paper prototype
All (3)	Take survey
Program	Search for plants and descriptions (2)
Learning how to make an app	Anything (5)

Source: prepared by the authors.

When asked what they liked most during the process of making their app, students pointed out the visual design process (Table 3). It is also observed by the students' responses that, in general, it was a very positive experience, with 3 students indicating that they liked everything and 5 saying that there was nothing they did not like. Two responses indicated that what they liked least was related to specific research on plants, an app has a mini encyclopedia of plants, something specific to the app chosen to be developed.

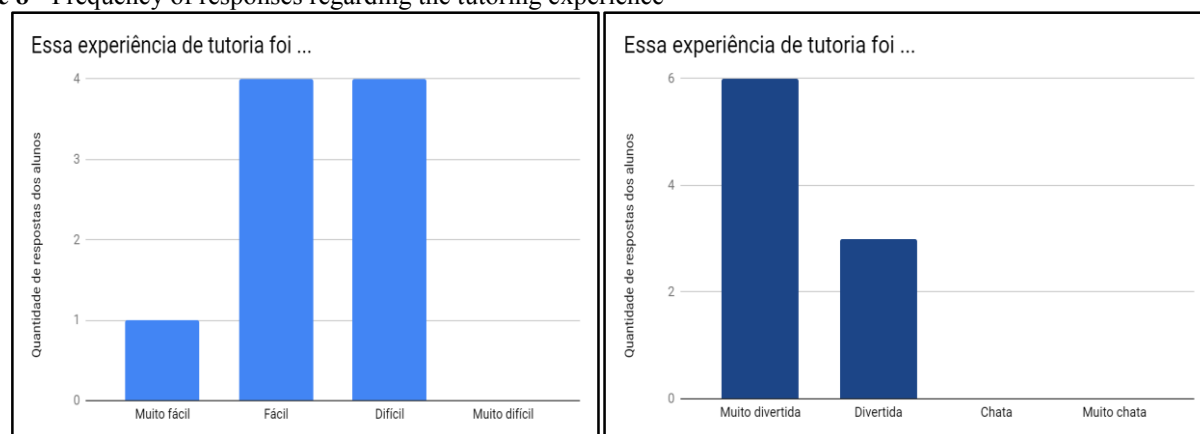
**Table 4** - What did you think of this experience?

What did you think of this experience?
Very cool, we acquired a lot of knowledge
Cool
An experience that was never to be forgotten. The classes and workshops were also very top
I thought it was really cool and fun
I found the experience of making an application very cool and fun
Very cool
Very cool, I liked it too
Super Cool
Not identified

Source: prepared by the authors.

From these answers, it is evident that the experience was considered positive by the students, contributing to their construction of knowledge, in a manner close to their interests using digital technologies.

According to the responses to the questionnaires, the experience of being a young tutor also presents significant aspects for the students (Figure 8).

**Figure 8** - Frequency of responses regarding the tutoring experience

Fonte: elaborado pelos autores.

The students considered the tutoring experience almost equally as easy and difficult at the same time (Figure 8). Such responses can be understood in the respect that explaining content to other students requires a diversity of communication skills, in addition to a good domain of skills encompassing technologies, which is something still in process in K9. On the other hand, regarding the question on if the students regarded the experience as pleasant, all responses were positive. Thus, the responses indicate positive results regarding the research question, demonstrating that the pedagogical practice of teaching computing through the development of mobile applications, as adopted in the Young Programming Tutors project, contributed positively to the interest and motivation of students in K9. We can also observe that

these positive aspects collaborate as a first step towards the construction of knowledge and that the development of pedagogical practices with attention to interests and motivations of students favors their role within the learning process.

## Final Considerations

The exploratory case study shows evidence that the pedagogical practice “Make your first app” demonstrates positively, through the evaluation of the students' experience, that the Young Programming Tutors project can contribute to the learning of computing. The adoption of the computational action approach, creating the challenge of developing a mobile application seeking to solve a problem in society, has been shown to contribute to the significant learning of students in the digital age. Such perspectives tend to strengthen the construction of students' knowledge and skills development, encouraging the construction of information technology solutions instead of just consuming technology.

Combining pedagogical practices with solving day-to-day problems can contribute to the development of research through curriculum content in an interdisciplinary, collaborating approach in the school context. And in the digital age, with the massive presence of mobile devices in people's lives, pedagogical proposals with smartphones and tablets are alternatives for the development of activities with digital technologies.

In this regard, the use of App Inventor, a visual programming environment based on blocks, facilitated the students' approximation with the learning of computing, arousing their interest already in K9, due to the development of functional applications.

Thus, the application brought significant results, indicating the potential that may be developed by teaching computing in K-12. However, there is still a lack of both theoretical and practical research, especially in Brazil, for comparison and analysis purposes.

However, we can conclude that based on the results of the Young Programming Tutors project, pedagogical practices encompassing the teaching of computing tend to contribute to the interest and motivation of students in the school context, and, consequently, can collaborate to the development of skills and abilities in the 21st century.

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## Notas

<sup>1</sup> The Logo language was created around 1960, seeking to aggregate the interaction between student and computer in solving problems.

<sup>2</sup> Apps are available on the Google Play store.

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