PRÁCTICAS CON TECNOLOGÍA EN LA FORMACIÓN DEL PROFESORADO DE MATEMÁTICAS PARA AFRONTAR NUEVAS DEMANDAS CURRICULARES

Practices with technology in mathematics teacher education to face new curricular demands

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Resumen

La importancia de utilizar la tecnología para promover el aprendizaje de las matemáticas ha sido señalada por la investigación en educación matemática y se ha expresado en el currículo de matemáticas del siglo XXI. La tecnología debe usarse para ampliar los contextos y la meta para el aprendizaje de las matemáticas de los estudiantes. Los docentes deben estar bien preparados para realizar la enseñanza con tecnología potenciando el estudio de los conceptos matemáticos y el desarrollo de habilidades. Este artículo se enfoca en dos contextos de formación docente, un curso en la licenciatura y la práctica de futuros docentes en prácticas durante la maestría, con el objetivo de comprender cómo los futuros docentes valoran las prácticas con tecnología enfocadas en la enseñanza de las matemáticas. Se presentará el trabajo realizado por los futuros docentes y sus reflexiones para discutir los aportes que la formación docente puede hacer para un desarrollo docente que enfrente las nuevas demandas.

Palabras clave: *aprendizaje, currículo, formación docente, matemáticas, tecnología.*

Abstract

The importance of using technology to promote mathematics learning has been pointed out by research in mathematics education and been expressed in mathematics curriculum of the 21st century. The technology should be used to enlarge the contexts and goal for students' mathematics learning. Teachers must be well prepared to conduct teaching with technology enhancing the study of mathematical concepts and the development of skills. This paper focus on two contexts of teacher education, a course in the bachelor and the preservice teachers' practice in the internship during the master's degree, with the aim of understanding how future teachers value practices with technology focusing on teaching mathematics. The work done by future teachers and their reflections will be presented to discuss contributes that teacher education could do to a teacher development that faces the new demands.

Keywords: *curriculum, leaning, mathematics, teacher education, technology.*

INTRODUCTION

The importance of using technology to promote mathematics learning highlight by research in mathematics education and this relevance is pointed to mathematics curriculum of the 21st century (Golding, 2023). NCTM (2014) pointed out to the integration of technology in the curriculum with the aim of assisting students learning, reasoning and communicate that reasoning. This document highlights that the technology in the classroom must be used to an effective mathematics teaching where students are involved in an active learning, solving problems and expanding their understanding. In 2022, in Portugal, a new curriculum for basic education comes (grades 1-9) with three main principles: "Mathematics for all", "The mathematics is unique but not the only one", and

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"Mathematics for 21st century" (Canavarro et al., 2021). This new curriculum clearly pointed to the use of technology in mathematic lessons. In this context, technology should be used to enable deeper analysis and exploration that would otherwise not be possible, and to encourage the exploration of multiple representations. Teachers must be well prepared to conduct teaching with technology enhancing the study of mathematical concepts and the development of skills. This paper focus on two contexts of teacher education, a course in the bachelor and the preservice teachers' practice in the internship during the master's degree, with the aim of understanding how future teachers value practices with technology focusing on teaching mathematics.

BACKGROUND

The technology should be used to enlarge the contexts and goal for students' mathematics learning. The use of digital resources should focus on providing students with an active role in learning and the development of knowledge, skills, values and attitudes, and not only on appealing aspects (Huang et al., 2020), nor be an end in itself (Canavarro et al. 2021). Huang et al. (2019) present four types of educational use technology that could be considered by teacher education: (1) for inquiry; (2) for communication; (3) for construction and problem solving; (4) for knowledge representation. So, the digital technology should be used to enhance mathematics learning with meaning for the student (NCTM, 2014), engaging them to explore mathematical idea in a more meaningful way for students, promoting their mathematical reasoning and commutation. Technology can foster the use of multiple representations (Artigue, 2021), helping to create meaning and connection between representations and concepts (Golding, 2023). Golding also highlights the role of technology in bringing out external connections: "digital technologies can bring external expertise into the classroom, and build wider digital literacy, potentially enhancing both curriculum coherence and its relevance to current wider issues" (p. 185).

The curriculum in Portugal express that the use of technology can also be linked to the development of computational thinking, which is consistent with what Golding (2023) express. Such articulation should focus on problem solving, in particular those related to programming. Portuguese curriculum guidelines are based on five practices: abstraction (seeing a problem at different levels of detail), algorithms (predisposition to see tasks as smaller interconnected steps), decomposition (solving a problem involves solving a set of smaller problems), pattern recognition (seeing a problem as related to previously encountered problems) (Hoyles & Noss, 2015), and debugging (ensuring that the solution works without errors and successfully responds to the given task) (Ng & Cui, 2021). In recent years, several digital tools have emerged that are suitable for working with students from elementary school, such as visual programming environments, by reusing and remixing projects, extending existing codes to create new or more complex projects, as mentioned by Ng and Cui (2021), and the robotics and programming contexts, as state by Sáez-López et al. (2019).

Regarding technology for teaching mathematics, the professional development should provide a deep understanding of how to use it to enable students to investigate mathematical ideas, solve problems, have a better understanding and are to link multiple representations (NCTM, 2014). Clark-Wilson et al. (2020) reported that research is needed to understand what professional development can support teachers in integrating technology in their lessons, as teachers felt that the opportunities they have had were not relevant to their experience in classroom, claiming the need of practical and adaptable resources. So, is important to include and strengthen the use of technological resources and related pedagogical strategies in teacher education (Varela & Desiderio, 2021). Teacher education should include approaches that enable teachers and future teachers to respond to the different learning needs of students (Nasri et al., 2020; Varela & Desiderio, 2021) and the existence of limited digital learning resources, such as devices or internet access (Nasri et al., 2020). With new curriculum, it's important that teacher development focus on subject and resources consistently with the values and approaches of the curriculum (Golding, 2018). For teachers it could be meaningful to know more about technological resources for teaching and also specific software to be used by students. Thurm and

Barzel (2022) identified teachers' beliefs about teaching mathematics with technology in a study involving 198 secondary school teachers in Germany. The results present three clusters of sub-dimensions: i) more integrated and constructivist implementation of technology, with self-efficacy; ii) use of technology to support multiple representations, and iii) teachers' beliefs about the detrimental effects of teaching with technology. This third group is less central, showing a greater importance of beliefs about the potential benefits of technology. Their results could inform approaches to teacher professional development. They reported that group two can be considered at an early stage. However, what concerns group one should be understood as an evolutionary process, being integrated in a gradual way in the teacher's professional development with implications in their teaching practice, since lesson design and implementation are central aspects.

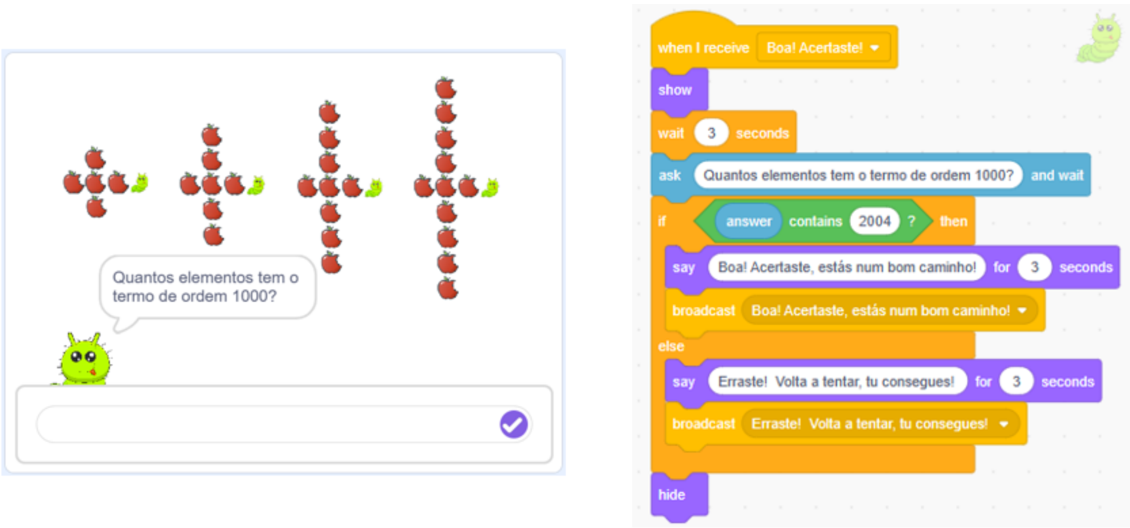
SCRATCH AND EARLY ALGEBRA IN TEACHER EDUCATION

The bachelor on basic education of Higher School of Education of Santarém has a course that integrates topics of early algebra. Considering the new curriculum demands, a group work to carrying out a Scratch project that integrated some of the topics covered in the course was proposed to prospective teacher. They were organized in 13 small groups (identified as PTG1 to PTG13) and each one defined the topic and the aim of the project. In a class, each group presented the Scratch Project, the main mathematical ideas that were involved and a collective reflection about the work developed. The groups prepared a written document that support their presentation. That document and observation of that presentation moment were the instruments to collect the data. The main objective is that prospective teachers develop their skills in Scratch and recognize the potential of the tool to be used by students to develop their algebraic thinking from the early years. It's important that prospective teachers recognize the mathematical ideas and mathematical skills that are involved in the construction of a Scratch project related with topics of early algebra.

Examples of Scratch projects developed

All groups selected the topic of sequences, focusing seven groups on repetitive sequences and six groups on pictorial growth sequences (with a linear growth). The tasks proposed in the projects were essentially the following: i) Ask the player to enter the term that is in an order given by the project and the project return if the answer is or is not correct. Some ask for a near term and others for a distance term (Figure 1); ii) Ask the player to enter the order of the term they want to know, and the project returns the term of the sequence that is in that order (Figure 2 and Figure 3).

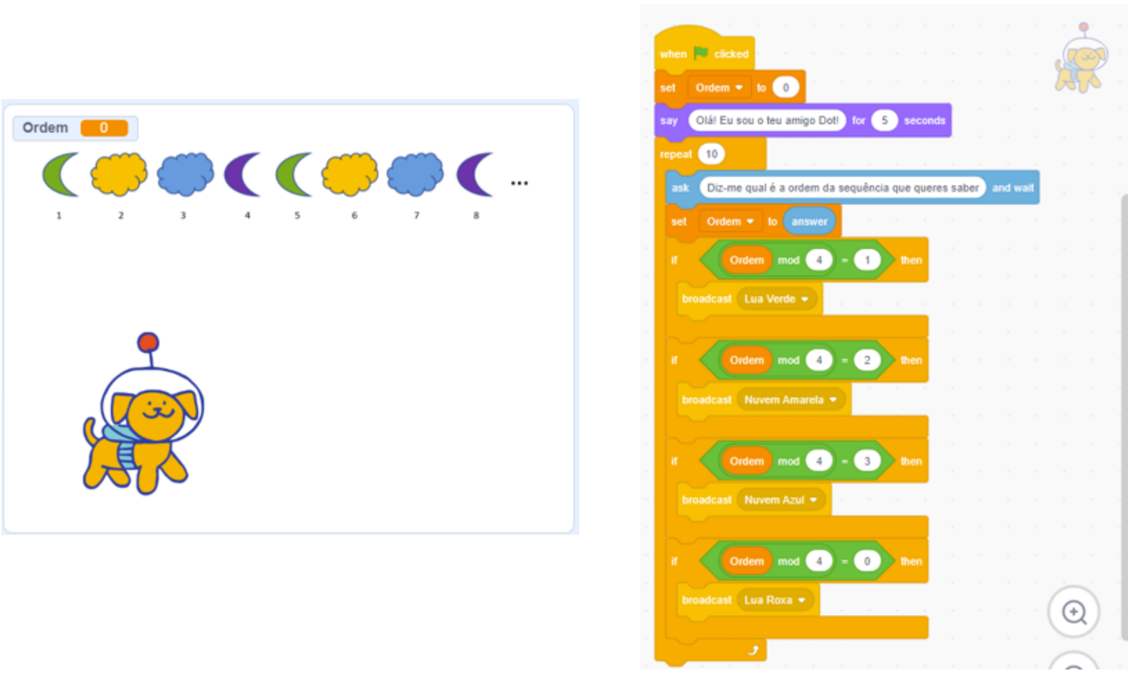
Figure 1. Task of a Scratch project to identify a specific term of the sequence (PTG13).



To construct the project the prospective teacher need to understand the sequence previously to correctly introduce the code to verify if the answer entered by the player is or is not correct.

The next two projects exemplify programs created by PTG related with repetitive sequences and pictorial growth sequences. When they work with repetitive sequences emerge the knowledge about division and the role of the rest (Figure 2). The divisor is the number of elements of the repetitive set. For each possible rest of the division one element of the first set of elements is associated. In an order that the rest is 1 the term of the sequence is equal to the first one, in an order that the rest is 2 the term is equal to the second term of the sequence, and continuing to an order that the rest is 0, the order is a multiple of the cardinal of the repetitive set, and the term is equal to the lest term of the set.

Figure 2. Task of a Scratch project with a repetitive sequence (PTG11).



In the Figure 3 it's possible to see that the PTG1 introduced a variable to associate the number given by the player to the order (fig. number). Then they used the variable in a general expression that directly calculate the number of pieces in that order.

Figure 3. Task of a Scratch project with a pictorial growth sequence (PTG1).

In both situations, Scratch enhances pattern recognition and generalization and other practices of computational thinking were essential to correctly complete the project.

Prospective teachers view about their experience

The different PTGs identify several contributes of this proposal for their development as future teachers. Some are related with their own knowledge, content knowledge, pedagogical knowledge and also curriculum knowledge, and others with students learning, involvement and motivation. Some groups analyzed the primary school curriculum to better understand the link between the work they did and primary students learning. Table 1 presents some ideas expressed by PTGs:

Table 1. Contributes identified by PTGs.

Main ideas	*PTGs*	
Improve their skills in using Scratch	PTG2, PTG3, PTG8, PTG10.	"We also improved our game programming skills." (PTG8) "This project allowed us to learn how to work and explore the Scratch program. By exploring the software we were able to better understand its operation, its commands and with this we were able to overcome those challenges." (PTG10)
Recognize the potential of the digital platform in teaching-learning and specific course content that can be worked with Scratch.	PTG1, PTG2, PTG5, PTG6, PTG7, PTG9, PTG10, PTG11. PTG12, PTG13.	"The development of this project allowed the group to explore and create a game on the Scratch platform, understanding the potential of digital platforms for teaching mathematical and computational concepts." (PTG1). "It made us explore contents that we will teach and recognize the importance in the development of algebraic thinking, the stimulation of creativity and the opportunity to work on different mathematical concepts." (PTG5) "With this project we also worked on the themes related to multiples of 4, and consequently, the issues related to divisions, because to obtain the dinosaur of the order we want we have to perform a division and, according to the rest we obtain, it corresponds to a respective dinosaur." (PTG7)
Knowing a tool that brings greater dynamics in class	PTG3, PTG8, PTG12, PTG13.	We learned a new strategy to work mathematical contents in a more dynamic way, using the Scratch platform. (PTG8) This platform is an advantage, because we can approach the subject in a more dynamic way and that captures the attention of the students better. (PTG12)

The PTGs considered very relevant this experience, valuing the opportunity to develop their own project as a game to promote mathematics learning. They value aspects related with their knowledge about the tool, and the opportunity the develop their knowledge related with some topic of the course, content that they will teach in their future practice. So, globally they expressed better understand the potential of the Scratch for teaching and learning mathematic and the challenge of creating tasks related with the specific topics: "The choice of questions was somewhat laborious, since it was for a specific age group. The exercises provided by the teacher and carried out in the classroom were a strong help and made it easier to choose them" (PTG10).

In general, several PTGs (PTG2, PTG4, PTG5, PTG11, PTG12.) recognized the contribute of the experience for their practice: "Knowing that, professionally, it will be an asset as future teachers and educators" (PTG2) and "This learning will be useful in our professional future, because in this we can create different types of games, thus approaching different [mathematical] themes, as this is an interactive and intuitive platform" (PTG4).

DIGITAL RESOURCES IN MATHEMATICS TEACHING DURING PANDEMIC

In 2020, during COVID-19, several schools in Portugal were organized to continue the lessons online. The internship is integrated in initial teacher education and is a requirement to become a teacher. So, during that period, in my institution, the Higher School of Education of Santarém, the standard internship model (presential at the schools) was adapted to an online internship process (Branco et al., 2022). This section focuses the particular work in mathematics teaching of two preservice teachers (PSTs), identified as PSTA and PSTB, that performed their internship in pair during the emergency remote teaching. PSTs enrolled in the master's degree with the purpose of becoming primary and middle school teachers of mathematics and sciences (6- to 12-year-old students). That internship was developed in a grade 6 class (11- and 12-years-old students). The data were collected from PSTs' collaborative written reflections on the practice, PSTs' individual reflections and an interview in the end of the internship.

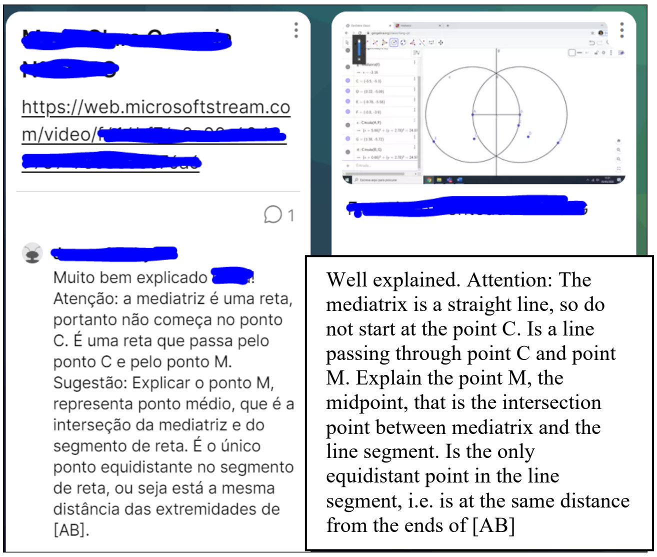
Example of GeoGebra usages

PSTs used GeoGebra in mathematics lessons for knowledge construction and problem solving. Initially they promote students' learning on how the features of this digital educational resource should be used, and then proposed tasks for student learning about geometry.

> The GeoGebra application was used either by the students or by us. Students were challenged to use this resource to understand the properties of the mediatrix…. We used this application during the internship to demonstrate the properties and characteristics of geometrical figures. (PSTs; Collaborative reflection)

PSTs explained the use of GeoGebra to explore isometries, such the rotation of a figure, and the construction of a mediatrix of a line segment. All students made videos using GeoGebra and explaining what they did to solve each task proposed. The students shared their work on Padlet and PST gave them feedback, as illustrated in figure 4 for mediatrix construction task.

Figure 4. Padlet with GeoGebra students' work and PST feedback.



PSTs feedback focused on vocabulary and the correction of the concepts involved. Being a dynamic environment, GeoGebra helped students to visualize the geometric properties in several situations, as PSTs identified.

Preservice teachers view about the use of GeoGebra

The PST recognized that the context of online teaching encouraged them to use a greater number of and more diversified resources. About the GeoGebra, PSTs identified the important role for visualization, mentioned that "it had become essential in Mathematics classes, in the field of Geometry and Measurement, more specifically in isometries" (PSTA; Individual Reflection).

This experience made the PSTs increase their pedagogical knowledge regarding the creation and use of digital resources to explore mathematical ideas, to promote an active participation of students and to diversify assessment instruments, from a formative perspective. One of the PST identify in her individual reflection that had the opportunity to: "learn new applications, their purpose and how they work. This learning is central to my future practice, with technologies increasingly present in our lives, and in teaching" (PSTA; Individual Reflection).

They used resources that they already knew form previous courses in teacher education program and, also, new resources. The PSTs had the support of the in-service teacher and the teacher educators who supervised the internship, and who discussed ideas, shared resources, and helped them in the initial approach during the planning. They appreciated the diversity of resources suggested to them to address specific content and the availability of supervising teachers to support their exploration. They report that support:

> They [supervisors] support with new resources and, also, with applications that we had already used, such as GeoGebra, they help with the use itself. . . [A teacher educator] spent a lot of time to help make a simple demonstration that would last about fifteen minutes of a class" (PSTB; Interview).

The time they needed to spend on resource preparation was a constraint they identified. The internship was an important context for PSTs developed their knowledge about different digital resources and recognized their contribution for students learning.

CONCLUSION

Teacher education has an important role to play in enabling teachers to meet the challenges of mathematics education for the 21st century, particularly regarding teaching mathematics with technology. The nature of the two examples presented is clearly different. The first one highlights the role of prospective teachers in the exploitation of a specific tool. They recognize the importance of creating a project in Scratch to deepen their knowledge of the tool and the relevance of using the tool to explore specific mathematical ideas, in this case involving sequences and computational thinking. The second example, even though it took place during the period of remote emergency teaching due to the COVID-19 pandemic, shows a great involvement of preservice teachers in using digital resources to promote students' mathematical learning. In this internship context the creation of digital resources, planning and implementation was very relevant. They used several new tools and valued the knowledge they had of tools they had worked on throughout their teacher education program, which they now used in their practice. In both examples, they recognize that the work supported during their training can be useful in their future practice and can give them more confidence in their practice because there is a greater knowledge of technology and its potential for learning mathematics. In future work, it would be pertinent to continue to accompany these future teachers and understand what use they make of technology in their practice over time. The experience that can be provided to future teachers during their teacher education should consider the curricular demands and involve them in experiences that contribute to deepening their knowledge of the use of technology in mathematics teaching.

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