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Interactive e-books on math learning objects in scratch for early years teachers

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ABSTRACT

Using digital technologies in mathematics classes can benefit student learning when the technologies are methodologically contextualized and aligned with curriculum content. However, this can be challenging for teachers because they need to learn about these technologies, consider their pedagogical use, and find time for self-training. To support teachers in meeting the skills and thematic units of the National Common Core Curriculum for Mathematics in the Early Years, we have developed a collection of interactive e-books that demonstrate the use of learning objects from the Scratch repository as an alternative digital technology for mathematics classes. This article presents the ideation and creation process of this material, its particularities, organization, and learning needs for development. Our goal is to inspire other teachers in similar creative processes. We identified the importance of adhering to an instructional design model, improving our knowledge of certain applications, and planning and reflecting on the elements included to make them appealing for classroom use. Professors who teach mathematics voluntarily analyzed the collection of interactive e-books and pointed out that it uses clear, didactic, interactive, and motivating language to learn and apply Scratch Learning Objects. They also highlighted its practical usefulness, articulation with the National Common Core Curriculum, and potential for pedagogical engagement.
KEYWORDS: Digital Technology in Education; Self-training; Mathematics Education.

E-books interativos sobre objetos de aprendizagem de matemática no *scratch* para docentes dos anos iniciais

RESUMO

O uso de tecnologias digitais em aulas de Matemática pode beneficiar o aprendizado dos estudantes se metodologicamente contextualizado e alinhado aos conteúdos curriculares. Isso pode ser um desafio para os docentes em função da necessidade de conhecer essas tecnologias, pensar no seu uso pedagógico e encontrar tempo para a sua autoformação. Com o intuito de colaborar com esse processo e auxiliar os docentes no atendimento às habilidades e Unidades Temáticas da Base Nacional Comum Curricular para a Matemática nos Anos Iniciais, desenvolvemos uma coletânea de *e-books* interativos que tratam do uso de Objetos de Aprendizagem do repositório do *Scratch*, apresentados como uma alternativa de tecnologia digital para as aulas de Matemática. Este artigo apresenta o processo de ideação e criação desse material, suas particularidades, a organização e as necessidades de aprendizado para elaborá-lo, no intuito de inspirar outros docentes em processos criativos análogos. Constatamos a relevância da adesão por um modelo de *Design* Instrucional, a necessidade de aprimoramento do nosso conhecimento de alguns aplicativos, assim como a importância do planejamento e da reflexão sobre os elementos inseridos para que eles sejam convidativos à sua inclusão em sala de aula. A coletânea de *e-books* interativos desenvolvida foi analisada de forma voluntária por professores que ensinam Matemática, e eles apontaram que ela possui uma linguagem clara, didática, interativa e motivadora para a aprendizagem e aplicação dos Objetos de Aprendizagem *Scratch*. Além disso, eles destacaram sua utilidade prática, sua articulação com a Base Nacional Comum Curricular e seu potencial de engajamento pedagógico.

PALAVRAS-CHAVE: Tecnologia Digital na Educação; Autoformação; Educação Matemática.

INTRODUCTION

When asked about his relationship with the media, Brazilian educator and philosopher Paulo Freire said, “One of the most pitiful things for a human being is not belonging to their time. It is feeling like an exile in time" (Freire & Guimarães, 2013). Reflecting on today's society, where digital technologies are prevalent, it's clear that professors and students must engage with this reality.

However, incorporating digital technologies (DT) into their daily lives in a pedagogical way can be challenging for teachers. This requires continuing education for teachers on the use of these technologies in the classroom, as research by Silva and Souto (2019) has already pointed out. For teachers of mathematics, this challenge may lie in identifying DT that can contribute to defined educational objectives and facilitate their learning. According to Almeida (2010), the pedagogical use of DT requires:

> [...] Professors need to take ownership of technology's intrinsic properties, apply them to their learning and teaching practices, and reflect on their use of technology. They should consider why and how to use technology and what contributions it can make to learning and curriculum development (p. 68).

In this sense, teachers must understand and be aware of their knowledge to develop a reflective view of it and of their teaching practice. Then, they can decide whether to include DT in their classes. This is a self-training process. According to Pineau (2014, p. 95), self-training enables "[...] a double appropriation of the power of training. It means taking this power into one's own hands — becoming the subject — and applying it to oneself — becoming the object of one's own training."

However, for this to occur, training and DT must be accessible to teachers and compatible with school infrastructure. With this in mind, we have developed a collection of interactive e-books to present teachers with an alternative digital technology to integrate into mathematics classes. E-books can be considered an evolution of printed books. They offer several advantages: the ability to be read on portable devices such as e-readers, cell phones, and computer screens (Kouis & Pouli, 2011); ease of access via the internet (Bottentuit Junior & Coutinho, 2007); environmental preservation through reduced paper use (Theisen & Pavão, 2019); ease of storage; and the ability to be read in dark environments (Boscarioli et al., 2020). Regarding e-book interactivity, Licht et al. (2016) highlight the diversity of resources, making learning dynamic and expressive.

This article presents the development of a collection of six interactive e-books that contribute to teachers' self-training in the use of Scratch Learning Objects (LO) in their mathematics classes for early elementary school students.

According to Marji (2014, p. 17), Scratch is a block-based programming language that "allows the creation of interactive projects rich in media resources, including animated stories, book reviews, science projects, games, and simulations." A notable feature of Scratch is that users can share their creations free of charge in its online repository. This makes Scratch a vast space for LO options involving activities, games, and content presentations, primarily focused on school subjects, especially mathematics. Professors can use these objects in their classes to facilitate the teaching and learning of mathematical content. It is

important to remember that no technology can replace the teacher, who can identify which technology is appropriate and when to use it.

There are six volumes because we studied official Brazilian educational documents and identified mathematics guidelines and skills for early years, as described in the National Common Core Curriculum (Base Nacional Comum Curricular) – BNCC (Brasil, 2018). These guidelines provide information on including DT in teaching practices and are intended for students.

The mathematics skills are divided into five Thematic Units: Numbers, Algebra, Geometry, Quantities and Measurements, and Probability and Statistics. To promote these skills, teachers must use DT with mathematical educational content and their own didactic methods to enhance student learning. Thus, the first volume addresses the initial steps of Scratch, while the subsequent volumes address each Thematic Unit (TU) and its specific features.

To ensure quality in the development process of the collection, we applied the principles of instructional design. According to Filatro (2008, p. 3), instructional design is "the intentional and systematic action of teaching that involves the planning, development, and application of methods, techniques, activities, materials, events, and educational products in specific didactic situations." Kenski (2015) adds that instructional design is the process of developing a teaching project involving strategic, technical, and creative actions guided by an intention, objective, or solution to a problem.

For this collection's development, we followed the five phases of the ADDIE (analysis, design, development, implementation, and evaluation) instructional design model proposed by Filatro (2008) and organized it into two stages: Conception, which involves analysis, design, and development; and Execution, which covers implementation and evaluation. The following sections present the methodological process of developing interactive e-books in accordance with these stages and their respective sub-phases.

METHODOLOGY – THE DESIGN STAGE

In this section, we will explain how we transformed the concept of an e-book into a collection of six. According to the ADDIE model of instructional design, Filatro (2008) divides the conception phase into three sub-phases: (i) Analysis: understanding the problem to be solved, identifying educational needs, characterizing teachers, and verifying restrictions (e.g., budget, deadlines, and available resources); (ii) Design and Planning: mapping and sequencing content, defining learning strategies and activities to achieve outlined objectives, selecting appropriate media and tools, and describing materials; and (iii) Development: structuring everything planned as an LO for teacher learning. 28); and (iii) Development, in which everything planned is structured as an LO for teacher learning.

We began the analysis sub-phase by developing a prototype of an interactive e-book and presenting it to the research Group on Technology, Innovation, and Teaching (Grupo de Pesquisa em Tecnologia, Inovação e Ensino - GTIE)[1], which consists of teachers working at various school levels. Through debate, we determined that some information would be specific to each Thematic Unit of the

BNCC for Mathematics. This required developing a volume for each unit, as well as an e-book presenting the first steps in the Scratch repository.

To understand the ways in which mathematical knowledge objects are presented, we consulted didactic books such as Akisino (2021), Dante (2017), Leite and Taboada (2021), and Santos (2017). We also read official documents that guide and regulate Brazilian education. These include the National Curriculum Parameters (Parâmetros Curriculares Nacionais) – PCN (Brasil, 1997); the National Curriculum Guidelines for the Initial Training of Professors for Basic Education and the National Common Base for the Initial Training of Professors of Basic Education (Diretrizes Curriculares Nacionais para a Formação Inicial de Professores para a Educação Básica e Base Nacional Comum para a Formação Inicial de Professores da Educação Básica) – BNCC-Training (Brasil, 2019); the BNCC (Brasil, 2018); and Computer Science – Complement to the BNCC (Computação – Complemento à BNCC) (Brasil, 2022). We read these documents to understand the expectations for presenting mathematical knowledge objects. We also examined the BNCC (Brazil, 2018) and Computing – Complement to the BNCC (Brazil, 2022) to understand the expectations for educational phases, Thematic Units, and skills development.

In the second stage of design, we analyzed and identified the elements and resources to be included in each of the six volumes of the collection and presented them in an instructional design matrix. According to Filatro (2008, p. 44), this instrument defines learning objectives for each item rather than teaching objectives.

We started with the instructional design matrix for the e-book First Steps — Volume 1 (Gonçalves et al., 2024a). The main objective of this e-book is to introduce Scratch to early years' teachers and help them search for LO in their repository. It also helps them include these resources in their mathematics lessons. Table 1 shows the summarized elements and resources used in the first e-book, along with the respective pedagogical intent.

Table 1

Instructional Design Matrix for the e-book Volume 1

Elements	Pedagogical Intentionality with the Element	Resources	Pedagogical Intent with the Resource
Presentation	Identify what LO is and what the purpose of the e-book is.	Image of an LO.	Allow a closer approximation to the standard image of LO Scratch.
The *Scratch*	Learn about Scratch, its LO repository, and how it can be used as a technology in mathematics classes to enhance student learning.	Image with the link to the Scratch repository.	Use the Scratch repository and allow for a visual identity similar to that of the software.
		Image of the result of a search in the Scratch repository.	View the search environment of the Scratch repository and the visual quality of its LO.
		Image with the link to a video.	Watch the video about Scratch, its repository,

			and a search for an LO.
		Video presenting Scratch, its repository, and a search for an LO.	Become familiar with Scratch, its repository, and understand in detail how to search for an LO to address a specific mathematical topic.
A BNCC	Bring guidelines from the BNCC regarding the use of Digital Technologies in teaching Mathematics in the Early Years.	Image with a link to the BNCC.	Provide access to the BNCC.
Scratch Learning Objects	Know how to share an LO Scratch and know some options for objects in the repository with information about possible uses.	Image of LO sharing.	Know how to share a Scratch LO with students.
		Images of Scratch LO with guidance texts.	Become familiar with some Scratch LO options with information on how they can be integrated into mathematics lessons.
LO Catalog	Be familiar with the catalog that groups LO Scratch for Mathematics by school year and TU, indicating the BNCC skills that can be developed.	Image with a link to a video.	Access and use the LO Scratch catalog for mathematics by school year and TU, indicating the BNCC skills it helps develop.
		Link to Gonçalves (2021), document containing the catalog.	Become familiar with the catalog.
Final Reflections	Reflect on the possibilities for using LO Scratch, as well as on the teaching of Mathematics and the development of BNCC skills, and access the other volumes in the collection.	Images with links to other e-books in the collection.	Access and use the other volumes in the collection of interactive e-books.
References	Access the references used to create the e-book.	Link to references.	Become familiar with the documents used in the production of the e-book.
Appendix A – Applications Used	Learn about the applications used in the development of the e-book.	Images of the applications.	Identify the applications with their visual identities.
		Links to applications.	Learn about the applications through interaction.
About the Authors	Learn about the authors of the e-book.	Photo and link to the authors' Lattes CVs.	Get to know the authors, their academic backgrounds, and their bibliographies.

Source: Gonçalves (2024, p. 52).

Since the other e-books in the collection follow the same structure despite being aimed at each Thematic Unit of Mathematics, we developed a single Instructional Design Matrix (Table 2) for all of them. These volumes aim to provide guidelines for accessing the Scratch online repository, tips for searching for LO resources related to the specific Thematic Unit, and suggestions for integrating LO resources into mathematics classes. In Scratch, the element "Name of the Thematic Unit" indicates the following terms for Volumes 2, 3, 4, 5, and 6: Number in Scratch (Gonçalves et al., 2024b); Algebra in Scratch (Gonçalves et al., 2024c), Geometry in Scratch (Gonçalves et al., 2024d), Magnitudes and Measurements in Scratch (Gonçalves et al., 2024e), and Probability and Statistics in Scratch (Gonçalves et al., 2024f), respectively.

Table 2

Instructional Design Matrix for e-books Volumes 2, 3, 4, 5, and 6

Elements	Pedagogical Intentionality with the Element	Resources	Pedagogical Intent with the Resource
Presentation	Know the elements that will be presented in the e-book.	-	-
"Name of the Thematic Unit" in Scratch	Understand what the BNCC presents in relation to each TU in Mathematics and the specifics of LO searches in the Scratch repository.	Image with the link to the Scratch repository.	Use the Scratch repository and enable an approximation to the visual identity of the software.
		Image of the result of a search in the Scratch repository.	View the search environment of the Scratch repository and the visual characteristics of its LO.
		Image with the link to a video.	Watch the video about Scratch, its repository, and a search for an LO.
		Video presenting Scratch, its repository, and a search for an LO.	Become familiar with Scratch and the repository, and understand in detail how to search for an LO related to a specific mathematical subject.
		Chart with possible search terms.	Identify keywords related to the BNCC's TU for Mathematics and the skills to be used to find LO that meet them.
Scratch Learning Objects	Know how to share a Scratch LO and know some options for objects in the repository with information about their possible uses.	Image of LO sharing.	Know how to share a Scratch LO with students.
		Images of Scratch LO with guidance texts.	Know some Scratch LO options that meet the BNCC TU and their skills with information about

			the possibilities for integration into mathematics classes.
Lesson Plan	Recognize a way to integrate digital technology such as LO Scratch into TU's mathematics support services to enhance student learning.	Images of Scratch LO with guidance texts for use.	Know, for planning purposes, some options for integrating Scratch LO into the BNCC TU and their skills in mathematics classes.

Source: Gonçalves (2024, p. 54).

We are still in the design stage, but we have already entered the third sub-phase, development. Everything that had been planned has been produced. First, we defined the standardization elements, such as the template and covers for the e-books. We found a free Microsoft PowerPoint template online and modified it to best suit our presentation needs. We established guidelines for incorporating images of tips, learning objects, and external links created using the online tool Canva and the image editor GIMP (GNU Image Manipulation Program).

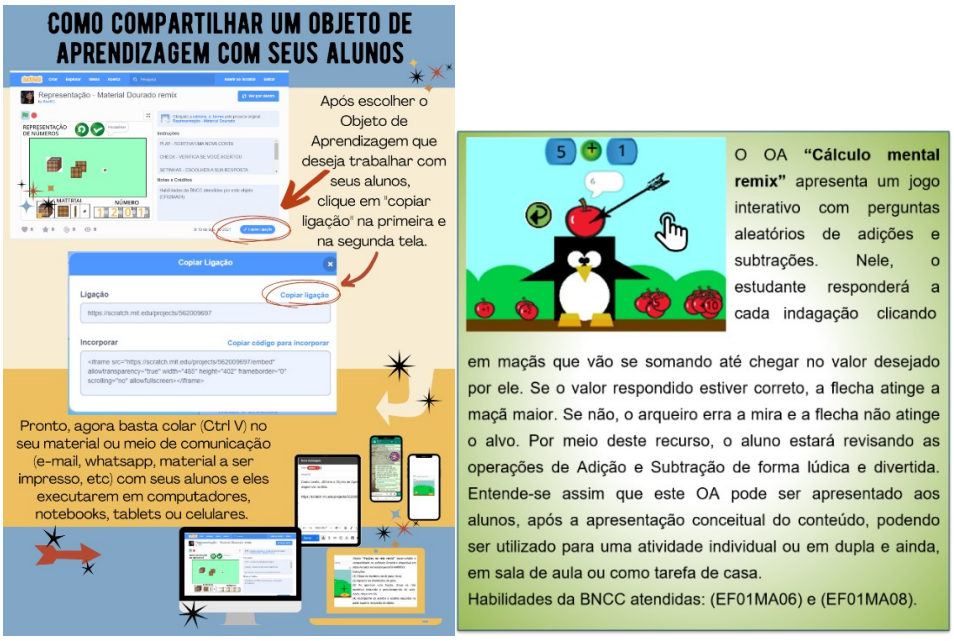
Although the volumes form a collection and follow a standard, we decided to give each one an identity. Thus, each received a different color and image of the Scratch cat on the cover, with that color used throughout. For some topics, such as "Creating an Educator Account on Scratch" and "Using Studios on Scratch," we recorded videos to support the teacher's learning process and included them in the e-books. We recorded these videos with Open Broadcaster Software (OBS) and made them available on the video-sharing platform YouTube. To create a consistent look, we developed animations in Scratch and used them as openings for these videos.

After defining all the information regarding standardization, we proceeded to draft the texts proposed in Tables 1 and 2 (Instructional Design Matrices). We started with Volume 1, which introduces teachers to the Scratch repository and explains how to use its LO when planning math classes. This volume contains information from the BNCC on the use of technology in math classes, a section with LO definitions and possibilities, and guidelines for sharing them with students. We also present an initial selection of LO from the Scratch repository with explanations of how they work, their potential uses in math classes, and the BNCC skills they help students develop (Figure 1).

We believe it is important to inform teachers about other digital technology options integrated into education. Therefore, we have listed the applications used to develop the e-books. We share this information so that teachers can use the applications if necessary and/or out of curiosity. We conclude this phase by providing links to the other volumes in the collection and information about the authors, repeating this information in all e-books.

Figure 1

*Sharing and Presenting a Scratch LO (*** Figures 1 and 2 will not be translated as the e-books are available only in Portuguese)*



Source: Gonçalves (2024, p. 62).

After completing the first volume, we moved on to developing the other five volumes, each with a pedagogical focus on the corresponding BNCC Thematic Unit for Mathematics in the Early Years. These volumes were developed in parallel, with each one presenting a section of the material.

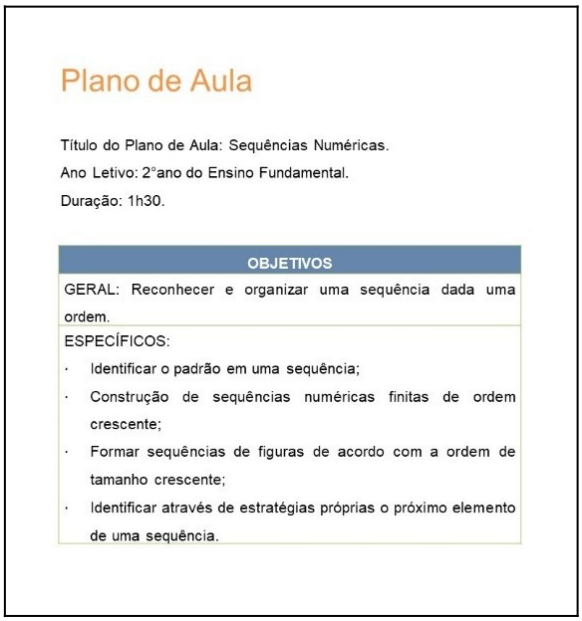
For each volume, we began by reviewing the BNCC guidelines for the related Thematic Unit to remind teachers of the specific information in that area of teaching. Next, we presented information on searching for Open Educational Resources (OER) in the Scratch repository that could be included in lesson plans to help teachers develop their students' skills in the respective Thematic Unit.

Each volume contains a section that lists the selected Scratch LO for the theme area. This section is accompanied by information on the LO' characteristics, functionalities, and possibilities for use in mathematics classes. It also includes the BNCC skills that can be promoted and guidelines on how to share the LO. Having heard the question, "How do I incorporate this technology into my class?" during previous teacher training experiences, we developed lesson plans integrating LO to inspire teachers using the e-books to create their own plans based on their teaching methods. Figure 2 shows the home screen of one of these plans, which is available in full in Volume 3 of the collection.

To develop these plans, we selected a school year from the early years of education, the Thematic Unit of the volume, one or more mathematical knowledge objects (content), and the skills to be developed with students in the BNCC. Using this information, we searched the Scratch LO repository for items that could contribute to developing these skills. After testing and selecting these items, we developed methodological paths and integrated them into the students' learning mediation.

Figure 2

First page of the Lesson Plan entitled "Numerical Sequences"



Plano de Aula

Título do Plano de Aula: Sequências Numéricas.
Ano Letivo: 2°ano do Ensino Fundamental.
Duração: 1h30.

OBJETIVOS
GERAL: Reconhecer e organizar uma sequência dada uma ordem.
ESPECÍFICOS: · Identificar o padrão em uma sequência; · Construção de sequências numéricas finitas de ordem crescente; · Formar sequências de figuras de acordo com a ordem de tamanho crescente; · Identificar através de estratégias próprias o próximo elemento de uma sequência.

Source: Gonçalves (2024, p. 65).

In each volume, we have included a section with tips on Scratch and presented the specific features of the repository. The repository contains numerous object formats developed in more than 150 countries (according to information on the website), so that a teacher can find an ideal LO for their class, but with the obstacle of it being in another language. Seeking to circumvent this situation, for the tip in Volume 4, for example, texts and videos were prepared showing how to make a few changes to alter written phrases and audio that are not in Portuguese to assist teachers who are using the collection and are not familiar with block programming. In each of the e-books, different tips were developed and presented.

Although the entire collection was developed in Microsoft PowerPoint, to make it available in a standard format that would not be misconfigured on other computers, we generated files in PDF (portable document format) and uploaded them to a shared folder on Google Drive. With that, once the sub-phases involving the Instructional Design stage were completed, the collection of interactive e-books was ready to be used. We then began the Execution stage, which involves the use and evaluation of the collection by teachers who teach mathematics in the early years, presented in the next section.

METHODOLOGY – THE IMPLEMENTATION STAGE

The execution stage involved applying or implementing the activity with the effective use of the teachers' collection of interactive e-books, followed by an evaluation in which they analyzed and reflected on the use of the developed resource. According to Filatro (2008), the implementation stage in e-learning is divided into two sub-phases: Publication and Execution. In our case, publication involved making the learning materials available in a shared folder.

To use and analyze the material, we defined our audience as mathematics teachers in the early school years, with no limitations on school year, training, physical location, or type of school. We created a promotional video inviting volunteers to register for the research study and published it on WhatsApp, Instagram, and Facebook. Registration was open from August 31 to September 11, 2023, resulting in 25 registrants.

On October 9, 2023, we contacted the registered teachers and sent them a link to the drive containing the e-books so they could download and use them. All communication took place via individual WhatsApp messages to answer questions and provide information about activities.

Next, we began the evaluation stage. According to Filatro (2008, p. 31), this stage involves seeking strategies and evaluating the educational resource and its learning outcomes. To this end, we developed an evaluation questionnaire about the use of interactive e-books using the Google Forms platform. The questionnaire contained open-ended questions, in which participants could respond in their words, as well as closed statements with response options based on the Likert scale (1932). "Strongly agree," "Agree," "Neutral," "Disagree," and "Strongly disagree." We developed the questionnaire using the Learning Object Evaluation Scale for Students (LOES-S) (Kay & Knaack, 2009), which categorizes resources based on three criteria: Learning, Quality or Instructional Design, and Engagement (involvement).

To identify signs of knowledge appropriation by volunteer teachers through interactive e-books, we sent the evaluation form via WhatsApp and asked them to respond. Data collection took place from November 6 to 17, 2023, yielding 15 responses, which were analyzed in Gonçalves (2024).

This research is part of a project approved on August 1, 2023, by the Human Research Ethics Committee of Unioeste under opinion no. 6,211,963. All participants were informed of the voluntary nature of their participation. Below, we present a reflection on perceptions related to the data collection process.

TEACHERS' REFLECTIONS ON THE COLLECTION

Based on participant feedback, we reflected on the need to adjust the collection of interactive e-books. Using the LOES-S scale (Kay & Knaack, 2009), we analyzed the responses and divided them into three categories: Learning, Quality, and Engagement. To preserve the teachers' anonymity, they were identified as P1 to P15 in the questionnaire and W1 to W25 in the WhatsApp interactions.

When analyzing their learning experience with the interactive e-books, the teachers reported that clarity, explanation, and fluidity of the texts were helpful. For example, P1 stated, “The e-books conducted the study with good fluidity and in a very explanatory manner,” and P14 argued, "I highlight how positive the explanations about LO were, since through their details, I already had a sense of whether they would be valid for my class."

In terms of the teachers' learning, emphasis was placed on using simple language to explain concepts and avoid the complexity of terms commonly used for DT. For example, P4 said, "In addition to helping teachers who are unfamiliar

with Scratch, it is written in easy-to-understand language that teachers can use in the classroom."

The participants highlighted the presentation of lesson plans that included LO, which they found relevant to their learning. P11 and P12 stated, respectively, "The plans are engaging, give meaning to the content, and provide inspiration for lessons and new activities," and "The fact that each piece of content is accompanied by a lesson plan involving a learning object is wonderful. It makes things much easier at the beginning since we are still developing our Scratch LO skills."

Information on which BNCC skills could be developed with students through each activity was presented alongside lesson plans and Scratch LO. Participants viewed this inclusion positively. For example, P9 said, "The presentation of BNCC skills allowed us to understand and plan lessons that met the planning requirements," and P12 stated, "In addition, the fact that each content item comes with a lesson plan involving a learning object is wonderful and makes things much easier at the beginning since we are still developing the skills to use Scratch LO".

Of the 15 respondents, five agreed and ten strongly agreed that the collection is intuitive and easy to use. We also asked if specific e-book items contributed to and added value to the content being covered. Twelve respondents agreed completely regarding the figures, and thirteen responded in the same way regarding the videos.

P4 highlighted the quality of the e-books, noting the interactivity and colorful material. Regarding the e-books' interactivity and format, participants pointed out that these features facilitated their learning by allowing them to study at their pace in their spare time. Among the various reports, we highlight those of P8 and P9. P8 stated that with the collection, "it is possible to return to the material as many times as necessary," and P9 said that the interactive e-books allowed them to learn at their pace. Participants also reported difficulties related to school infrastructure, lack of internet connection, and the inclusion of different activities in the school calendar, although these issues were not related to the resource.

Regarding quality, participants offered suggestions for adjustments and improvements. For example, P1 pointed out spelling errors that were immediately corrected. P10 requested that communication errors in one of the videos included in the collection be reviewed, and changes were made. Regarding quality, the Tips section of Scratch received lower ratings than the other items. Seven participants totally agreed with its relevance to their learning in these first activities with Scratch LO, while eight only agreed. Despite this result, we did not remove it from the collection because we believe these tips may be useful to teachers in future situations involving the Scratch repository.

In terms of engagement, participants reported feeling motivated to use the interactive e-books for learning and the Scratch LO in their classrooms. Regarding this, P14 said: "I want to congratulate the author of the e-books. The organization, design, and shortcuts caught my attention as a reader and made me interested in the content." Regarding the collection, P12 stated: "It's engaging. In a way, we have fun while learning how to use the objects." P2 added, "All of this is presented in a didactic and attractive way."

In the next section, in addition to the results found, we present our reflections on the experienced process.

RESULTS AND DISCUSSION

As a result, we developed and published a collection of interactive e-books available on the EduCAPES Educational Objects Portal. The link https://educapes.capes.gov.br/handle/capes/743857 provides access to Volume 1, which contains links to the other volumes. We believe this will help other teachers, in addition to those who participated in the research, see the LO in the Scratch repository as a teaching resource for mathematics education in the early years and for developing the skills and Thematic Units of the BNCC with their students.

We emphasize that developing material such as a collection of interactive e-books required learning about various topics. The first topic is the suggested digital technology: the LO in the Scratch repository, its particularities, and how to relate it to mathematical content and the BNCC requirements. To accomplish this, we had to understand the Thematic Units and Mathematics skills for the early years, as well as didactic methods of presenting mathematical content. Through this process, we improved our teaching practice and concurred with the findings of Almeida et al. (2023, p. 13). When discussing their experiences developing educational products, they stated, "the construction of the educational product [...] using didactic strategies associated with digital tools advanced our teaching practice due to the knowledge acquired through various didactic-pedagogical strategies, especially digital tools."

To create interactive e-books and include the desired resources, we had to learn how to use certain applications: Microsoft PowerPoint, the graphic design platform Canva, the image editor GIMP, the video recording software OBS Studio, and the video sharing platform YouTube.

To encourage other teachers to develop similar resources, free, intuitive applications were used to make the development process accessible to everyone, including those with little to no experience with digital technology. In addition to using these applications, it was important to investigate and understand information related to topics important for mathematics teachers, as well as how to present them to spark interest. The Addie model of instructional design helped us organize the content and tasks that needed to be developed, as well as the reflections and planning before including each piece of information and resource in the collection.

One challenge in developing the collection was putting ourselves in the position of teacher trainers and seeking to include information that would contribute to using DT in mathematics classes. Thus, we searched the Scratch repository to create a set of LO that exemplify their relationship with mathematical content and demonstrate how to share them with students. Considering that teachers were exploring a new possibility for DT in their classes, we presented suggestions for lesson plans that included Scratch LO alongside other pedagogical activities. This allowed these teachers to envision situations in which they could

apply their newfound knowledge, reflect on the presented material, and develop their own plans.

Regarding the participants' analysis, the interactive e-books were perceived as materials with clear language, detailed explanations, and a well-defined didactic structure. The teachers emphasized the ease of acquiring knowledge, despite it being digital technology, and highlighted that including lesson plans and articulating them with the BNCC skills facilitated the learning process. In terms of quality, the teachers rated the e-books as intuitive and easy to use, containing elements that contributed to learning. They highlighted the interactive nature of the collection as a facilitating factor because it allowed them to use it at their pace, at any time, and as often as they wished.

Regarding engagement, participants reported feeling motivated to use the e-books for their learning and to apply Scratch LO in the classroom. They emphasized the engaging, educational, and appealing nature of the material, which sparked their interest in reading and exploring the content. They also pointed out that the organization, design, and visual elements contributed to a more enjoyable user experience.

CONCLUSION

Developing a collection of interactive e-books to present digital technology for teachers' self-training in mathematics was challenging. One of these challenges was becoming familiar with the structural and aesthetic development of interactive e-books. In addition to technical knowledge, considerable thought was required for the content and presentation of each e-book resource, as the information needed to be appealing and accessible.

Adherence to the ADDIE model of instructional design helped ensure the work was conducted in an organized, sequential manner. This allowed for reflection on each resource before development and prevented the omission of important content elements.

We also concluded that more materials are necessary to assist teachers in their self-training process. These materials must consider teachers' daily lives, limited availability for training and knowledge acquisition, the precarious infrastructure of schools (which often compromises the implementation of some practices and technological inclusions), and compliance with the provisions of the guiding documents for education. In this sense, we understand that (i) describing the creative process from ideation to evaluation provides insights for developing new materials from an instructional design perspective, and (ii) the developed collection meets these needs.

Finally, possible future work includes developing other interactive e-books to present other DT to be included in mathematics classes, as well as similar materials for teachers in the final years of elementary and high school. Further research on teacher self-training with digital technologies is also necessary.

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1. GTIE official website: https://www.unioeste.br/portal/gtie/apresentacao

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