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Identifying Challenges for Elementary School Teachers in Building Digital Games through a Workshop

Joana Gabriela R. de Souza [**Federal University of Minas Gerais** | ***joana.souza@dcc.ufmg.br***]
Raquel Oliveira Prates [**Federal University of Minas Gerais** | ***rprates@dcc.ufmg.br***]

Computer Science Department, Federal University of Minas Gerais, Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte - MG, 31270-901 Brazil.

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Abstract To develop technologies that facilitate the creation and customization of digital educational games, this research aimed to explore the use of a game authoring tool by elementary school teachers and to identify the challenges and skills of this public using the tool. Our findings indicate that most of them had difficulties using it due to a lack of digital literacy and many possible configuration settings. They struggled with the steps they needed to complete in the tutorial and understanding concepts such as events, conditions, and actions. On the other hand, they were able to easily arrange the objects in the scenes. As a result, we present a set of recommendations that can be useful to construct new tools for this audience.

Keywords: Serious games, Educational games, Game development, Teachers as game developers, Digital literacy.

1 Introduction

Serious games are games used for more than just entertainment. Two main points characterize them: (i) they combine the game with one or some utility function (e.g., training or broadcasting a message), and (ii) they aim for a market different from entertainment (e.g., training and education) [Alvarez *et al*., 2011]. Among serious games are instructional games that can be helpful in the educational context, as they generate curiosity, fun, and motivation, facilitating learning and increasing knowledge retention [Foster and Shah, 2020]. Teachers often use games in their classes as a teaching resource, mainly in physical format [Guzzo, 2020]. Thus, as most students are already familiar with games, inserting them in a digital format becomes another way to bring engagement and motivation to help students retain knowledge.

However, developing digital educational games is difficult for teachers without knowledge of game design [Akcaoglu and Kale, 2016]. The production of serious games involves several challenges from game development (e.g., script, design, mechanics). It involves the combination of game design (which is already considered challenging [Kanode and Haddad, 2009]) and pedagogical aspects (purpose) of the game. The involvement of a professional development team makes it costly [De Gloria *et al*., 2014]. Therefore, allowing teachers to create and customize their own games is a way of making this process cheaper and allowing them to create more personalized experiences according to their needs.

The COVID-19 pandemic and the "remote emergency teaching" presented teachers with numerous challenges, including the adoption of unfamiliar technologies and the struggle to maintain students' engagement and connection, among other issues [Souza and Prates, 2022]. Considering this challenging period for teachers and their increased use of technology in their teaching, we decided to expose them to a game-authoring tool aimed at non-programmers, namely GDevelop. This study identifies Brazilian elementary school teachers' potential difficulties and competencies utilizing a game authoring tool designed for non-expert users. To do so, we conducted short workshops (two hours long) with teachers from our target audience in which we taught them to develop a simple educational game. The game developed was a quiz, as it is a well-known and simple game. The data was collected by observing the teachers' interaction with the tool and through a questionnaire about their experience with it. These workshops provided valuable insights into the experiences and perspectives of educators using game-authoring tools for educational purposes.

There are various obstacles to using digital games in schools. Some are related to technological resources, such as the incompatibility of operating systems with games and the lack of internet. Others are related to their adoption, where teachers may not have a clear enough understanding of the potential of digital games in education [Pereira and Rocha, 2023]. We aimed to tackle the problem of teachers seeing more potential in digital games.

One of our main goals was to increase the digital literacy of elementary school teachers in technology. We aimed to understand how these professionals would engage with such tools. By exploring their behaviors and experiences, we sought to gain insights that would enable us to provide better assistance and guidance in utilizing these tools for educational purposes. Furthermore, the insights from this workshop allowed us to identify the challenges teachers faced when using these tools and propose an initial set of recommendations on how they could be addressed in game-authoring tools for this audience.

During the workshops, we identified that the teachers had no experience developing digital games and needed help in developing them, even in a system aimed at users who are not programmers. We noted that technology use was not the

only problem they faced; the lack of computational thinking skills was also a problem. The teachers were interested in the workshop because they believe digital games are a helpful resource for students' daily lives. Although there were some activities they considered easy, in general, teachers faced many challenges in the guided use of the game authoring tool. Based on these challenges, we can discuss their implications both for increasing teachers' digital literacy and redesigning existing tools or developing new systems that seek to enable teachers to develop digital games.

In this paper, we have extended the paper presented at WEI 2023 - Workshop on Computing Education[1]. In this extended version, we have expanded our related works section, better contextualizing our research within the existing literature. We have also included a more detailed explanation of the methodology and tools employed. Regarding the results, we have included the analysis of a questionnaire answered by teachers considering their experience with the workshop. Furthermore, we have provided a more in-depth analysis of our results and extended the points and insights addressed in our discussion.

The article is organized as follows: next, we present the related works to this research (section 2), and then, in section 3, we present the methodology adopted in this work. In the following section, we present the results (section 4) organized in the three subsections that describe the participants' impressions of their experience and their use of the system - what was easy to use and the challenges faced. Then, we discuss the results and their implications (section 5). Finally, we present limitations related to the validity of our work (section 6) and the conclusions and final remarks (section 7).

2 Related works

Several works in the literature present initiatives in creating educational games by teachers, as pointed out in [McColgan *et al*., 2018; Becker, 2007]. However, in this paper, we highlight works that focus on teachers in the role of digital game developers. We highlight work such as that by [Barney and Leavitt, 2019], who conducted a study with elementary school teachers in the United States to integrate games into teaching. In the experiment, teachers were introduced to aspects of engagement in games of different genres. Popular games were presented to them to promote insights and contrast their approaches. Subsequently, the focus was on educational games in the genres of the games studied. The teachers also had to design a digital educational game during the course. Our study focuses more on teachers' use of a game-authoring tool and the experience of using it without prior knowledge of this type of tool.

Similarly, [do Prado *et al*., 2020] presented a study in which they created a course to teach game design to educators. The participants tried different game genres and discussed materials about game design, and at the end of the course, each student developed a physical board game. The authors discuss the low adherence to games as a teaching resource and the insufficient understanding of game design as reasons for their use. In this study, although they mention the development of digital games, the games developed by participants and presented are physical, and our focus is on digital games, which adds a new layer of abstractions that teachers need to consider.

Other studies have investigated teachers' challenges or experiences as game-authoring tool users. [Manuel *et al*., 2019] reported on a study with teachers and artists using u-Adventure, an authoring tool to create narrative adventure educational games. The participants were able to create the games using the tool. However, they had difficulties related to their lack of experience with narrative-genre games and doubts about effects and conditions, which are more frequent for those without programming experience. The authors of [Akcaoglu and Kale, 2016] held workshops on game design with undergraduate students to support teaching through games. At the end of the study, all participants indicated that they had developed a basic understanding of game design and programming and felt comfortable in the process. The authors found that those with more experience in using games and technologies found it easier and put more effort into the pedagogical aspects of game development than those who did not have much knowledge and spent much time trying to understand the software, taking the focus away from the educational aspects and how to introduce them into lessons. Our work aimed to explore the use of a game-authoring tool by elementary school teachers to create games. Our goal was to analyze whether it was easy for them to use the tool or if they faced challenges.

In the work of [Romero and Barma, 2015], the authors experimented with pre-service teachers [2] in Canada. The students were introduced to the Game-Based Learning (GBL) approach, which included games in their practice. They presented three strategies for including games: redesigning and customizing serious games, re-purposing existing games, and creating educational games as a learning activity. Most students opted for the first and second approaches (50 out of 51), making us think these strategies appeal more to the public than co-creating the games with their students. The pre-service teachers had never been introduced to GBL and considered it a good approach to work on the competencies needed in primary education. Our work is situated in a different context, dealing with the Brazilian scenario and in-service teachers.

We also found studies such as [Li, 2012] where the authors assisted 14 teachers enrolled in an undergraduate course at a Canadian university. The researchers used the theory of enactivism, based on learning by doing, to transform teachers into game designers for their audience, the students. In the study, they noticed the development in the teachers' creativity and a sense of taking advantage of learning in practice and collaboration with the students who were their "clients". In [An and Cao, 2017], the authors had 50 students from an online graduate course in the United States who are in-service teachers. In this study, the students had to create their game design document after four weeks of learning about GBL. At the beginning of the experiment, 20% of the participants had no in-

[1] Authors translation for the original title in Portuguese *Workshop sobre Educação em Computação*

[2] Students from courses such as pedagogy and other courses, where the student's goal is to become teachers

terest in developing their games. However, by the end, they all thought it was necessary to include teachers in the game design process and adopt their games in the classroom. Our work is based on a short-term observation – a 2-hour workshop. Thus, the goal was to analyze how Brazilian teachers would relate to a game authoring tool by creating a game they were familiar with.

In [Foster and Shah, 2020], the article highlights the educational benefits of GBL by fostering learning, promoting discovery, and encouraging diverse approaches. They conducted a systematic literature analysis focused on teachers' GBL interventions, investigating their pivotal role in these interventions. This analysis resulted in six principles guiding research and practice in GBL within teacher education. To enhance digital literacy, [Anisimova, 2020] conducted a course targeting future preschool teachers as a use case. The course comprised four modules: interactive didactic Games, animation basics, programming basics, and network technologies. The author asserts that digital literacy is crucial for 21st-century professionals, as higher proficiency in this area increases their inclination to incorporate information and communication technologies, including games, into their instructional practices. Despite efforts to promote digital literacy and integrate GBL in education, persistent challenges hinder its implementation. In a study focusing on pre-service teachers' perspectives, [Kaimara *et al*., 2021] identified critical barriers when using digital GBL. These barriers include limited financial resources, a preference for traditional teaching methods, stereotypical perceptions regarding the value of digital games, inadequate information and communication technology (ICT) training, insufficient infrastructure, and a lack of supportive policies and frameworks. The authors recognized that these perceptions are already documented in existing literature, reinforcing the need to address and overcome these barriers. The work of Toda *et al*. [2022] also reinforces teachers' biases about adopting strategies such as gamification.

The work of Degrandis *et al*. [2022] presents a methodology for training basic education teachers based on games, gamification, and computational thinking. The authors applied the methodology in teacher training by using games, gamification, and computational thinking. However, there is no focus on the development of digital games by teachers, which was our focus in this study, where we investigated teacher interaction with a digital game authoring tool.

Our work emphasizes digital literacy to enhance teachers' willingness to utilize ICTs. Similarly, we explore the use of GBL as a pedagogical approach. However, our approach involves placing teachers as primary contributors to game development. Through a workshop, we observed the reactions and experiences of in-service teachers adopting this technology, aiming to identify facilitators and the challenges faced. Consequently, we identified and proposed design recommendations for tools to assist teachers in this process.

3 Methodology

We opted for qualitative research as it enables us to conduct an in-depth and contextualized study, exploring and investigating with flexibility in procedures and techniques [Nicolaci-da Costa *et al*., 2004]. This work presents a qualitative analysis of a workshop conducted with elementary school teachers from Brazilian public schools, focusing on developing a digital educational game using a game authoring tool. Our research in this workshop aims to identify challenges, facilitators, impressions, and factors that aid in identifying requirements for tools that empower these professionals in creating digital educational games. Figure 1 shows an overview of the methodology adopted in this work. In this section, we describe each step of the methodology.

3.1 Outlining the objective

The research question being investigated in our study was: *"What are the challenges and skills of Brazilian public elementary school teachers using game authoring tools aimed at non-professional users?"*. The game authoring tool aimed at non-professional users selected for the workshop was GDevelop[3] in version 5.1.151 (Figure 2 depicts GDevelop's website).

GDevelop was chosen due to its popularity and features aimed at non-professionals in game development. It is based on a previous study in which a thorough tool analysis was conducted [Souza and Prates, 2021]. In preparation for the workshop, we generated a tutorial for developing a quiz-type game that explained, step by step, how to interact with the platform to create the game. We chose the quiz-type game because of its simplicity and the target audience's familiarity with this type of game. All the visual resources used in the game were made available to participants during the workshop. Developing a simple game was motivated by our goal to observe teachers' interaction with the tool and their understanding of concepts not to focus on creating a complex game.

We performed a pilot test via teleconference with an elementary school teacher, aged around 30, with more than five years of experience. The participant was chosen by convenience. We identified potential difficulties with the platform and the time it might take teachers to complete each task. Initially, the plan was to develop two games, a quiz and a platform game based on Brazilian tales. Still, based on the pilot test, we concluded that it would not be feasible for the duration of the workshop and

3.2 Ethical Concerns

Throughout our research, we observed ethical requirements by the Brazilian regulation, as well as any issues regarding participants' privacy and welfare[4]. First of all, the research project, including the study presented in this paper, was submitted to and approved by the Research Ethics Committee of the Federal University of Minas Gerais (UFMG)[5].

The first step, in the consent process was getting the informed consent from the schools. To do so, the research and

[3] `https://gdevelop.io`. Accessed on 08 Apr. 2024

[4] All the links to access the documents are available on the section Materials 7

[5] This research was approved by the Research Ethics Committee of UFMG (CAAE 55111522.9.0000.5149)

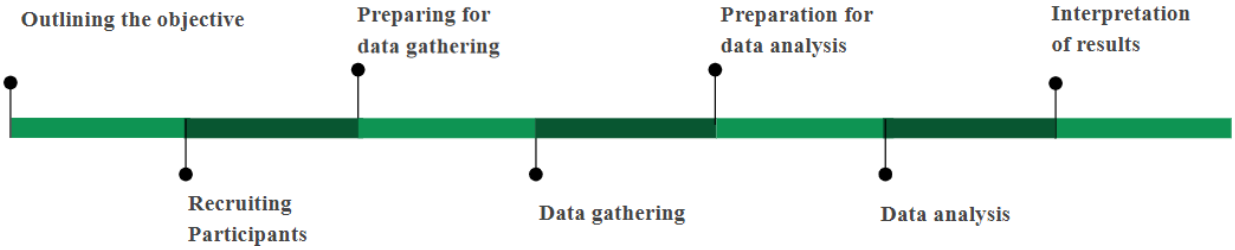

Figure 1. Methodology

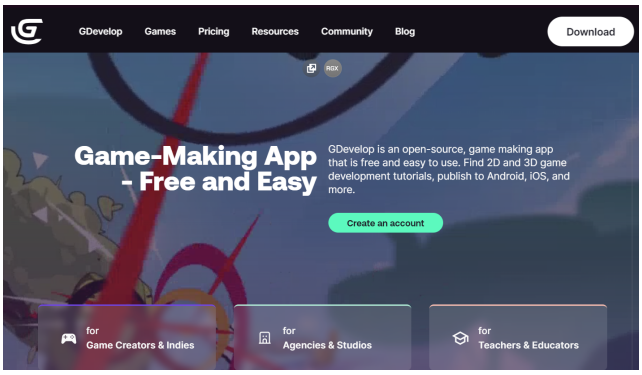

Figure 2. GDevelop website.

workshop proposed were explained to the school principal. They could ask questions regarding any doubts or concerns they had. To participate, it was required for the school to have a computer lab, in which the workshop could be conducted. If principals agreed, they were asked to sign a form consenting to the school´s participation in the data collection process.

Once the school had agreed to participate, teachers from these schools were invited to participate. The principal was responsible for inviting and/or selecting the teachers. The principals were informed that the ideal number of participants was around 6, which was previously considered a number that would be productive – i.e., the workshop instructor (the 1^{st} author) could support during the planned activities. The workshop took place during the teachers' "module II" period (a 2-hour period in which teachers stay at school to carry out planning and training, among other activities[6]).

The first step in the workshop involved explaining the research to teachers – the voluntary nature of their participation and making it clear that they could discontinue their participation at any time without any penalties from the researchers or school. The workshop instructor read the consent form to them, and they were encouraged to ask any questions regarding any doubts or concerns. If they agreed to participate, they were asked to sign the consent form.

The benefit to participants was learning how to create games using the GDevelop platform. They could also keep the instructional material for further use, and the game they created. The risks were mainly getting tired or feeling any physical or social discomfort during the workshop.

For the analysis process, the participants were anonymized, by substituting their names for a number. In this paper, we refer to participants as the letter 'P' followed by the number assigned to them.

3.3 Participants

We held three workshops in different schools and on different days, the workshops happened in November 2022. All the schools were part of the state educational system. In total 25 teachers participated in the workshops (W1: 11, W2: 8, and W3: 6). All the participants were female teachers aged between 30 and 60. The all-female participation was not by design[7]. The third workshop took place in a school in a rural area, the other two in urban areas.

In one of the workshops, one teacher decided to discontinue her participation, after around 30 minutes into the workshop. The instructor reassured her that it was not a problem and she was free to leave, without any problems. Although she was not asked to justify her decision, the participant mentioned that she was feeling anxious and nervous as a result of the activities.

3.4 Preparing for data gathering

Before the workshop, we installed GDevelop on the computers in the school laboratory and saved a folder on the desktop with all the assets used in the tutorial. We then opened GDevelop to reduce the teachers' efforts.

The tutorial described, step-by-step, how to build a simple quiz game entitled "*Super Quiz*". The game consisted of a "*start scene*" with buttons to play and exit the game (Figure 3(a)); three "*question scenes*" (questions created by teachers), each containing a question with three alternatives (Figure 3(b)); and a scene with the "*final result*" with the player's total points, and two buttons, one to return to the beginning of the game and another exit the game (Figure 3(c)). The plan was to explain each step of the tutorial to the participants, which would then perform that step.

At the end of the activity, the teachers were asked to fill out a questionnaire about their experience in participating. The questionnaire contained 12 questions[8]. There were four

[6]The State of Minas Gerais requires teachers to spend at least 2 hours a week in activities aimed at face-to-face training and capacity building. See: `https://escoladeformacao.educacao.mg.gov.br/index.php/26-portal-especialista/sala-de-leitura/108-atividade-extraclasse-modulo-ii`. Accessed on 08 Apr. 2024

[7]The all-female participation might be related to the fact that most elementary school teachers in Brazil are women. According to research conducted by the Brazilian Ministry of Education 77.5% of teachers in Brazil from grade 1 to 9 are women (see `https://www.gov.br/inep/pt-br/assuntos/noticias/institucional/professoras-sao-79-da-docencia-de-educacao-basica-no-brasil`. Accessed on 03 Apr. 2024).

[8]Form available at `http://tiny.cc/ahpevz`. Accessed on 08 Apr. 2024

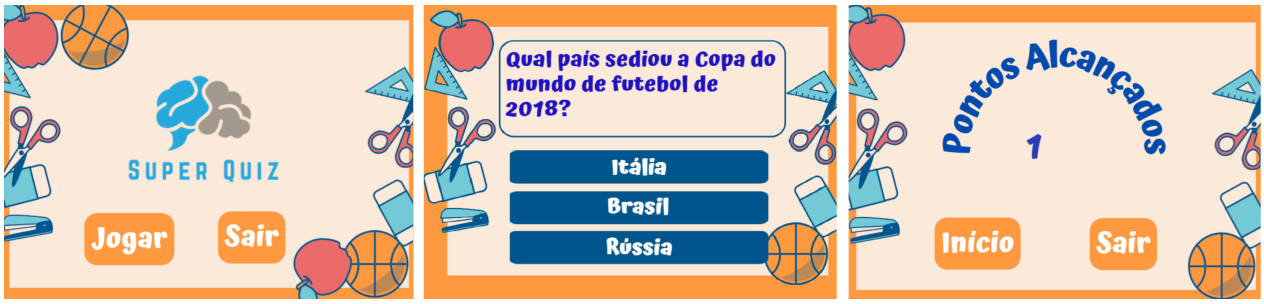

Figure 3. Game scenes: (a) Start scene, (b) Question scene, (c) Game over scene.

open questions about the participants and their experience as teachers. Next was a question about the participant's satisfaction with the workshop (Likert scale), followed by a multiple-choice question about their previous experience creating digital games. Then, there were three multiple-choice questions about how they characterized their learning of game development and an open-ended question about the challenges and benefits of their experience. Finally, they were asked if they would like to participate in other workshops and had any suggestions, doubts, or complaints about the workshop.

3.5 Data gathering

During the workshop, once the participants had signed the Informed Consent Form, the instructor presented the tutorial. She presented each tutorial step, which the participants had to follow simultaneously. Any questions that arose were clarified during the activity.

In addition, the instructor observed the participants, paying attention to how the teachers interacted with the system and whether they understood concepts such as scene, event, condition, and other aspects related to using the tool. She also took notes and recorded the audio of the environment. The tutorial presented to the teachers was sent to them by e-mail after the workshop[9]. They asked for it so that they could follow it again if they wanted to review any steps.

At the end of the workshop, teachers were asked to fill in the questionnaire about their experience. In the first workshop (W1), it was only possible to carry out some of the planned tasks due to a delay to start on the part of the teachers. The other two workshops (W2, W3) were completed. Thus, in our analysis of the questionnaires, we only considered the ones from participants of W2 and W3.

3.6 Data analysis

In preparation for the analysis, we transcribed the recordings and summarized the results from the experience questionnaire, and considered the instructor's notes. We then coded the material and classified the codes into categories (positive impressions and difficulties) to help us answer our research question. The results from data analysis are presented in Section 4.

[9]Tutorial available at: `http://tiny.cc/jfd7vz`. Accessed on 03 Apr. 2024

3.7 Interpretation of results

Next, we present the results of our analysis. To offer traceability to our interpretation, we have included quotes[10] from participants' comments during the workshop, as well as indicated aspects noted by the researcher conducting the workshops during the activities. In the next Section, we present the results, and then we present our discussion, in which we present an initial set of recommendations on game-creation tools for teachers.

4 Results

This section presents the results based on the data collected in the workshops. We exposed the teacher's impressions of participating and outlined the concepts or activities they found easy and the difficulties they faced.

4.1 Impressions collected from the questionnaire

At the end of the workshop, the teachers filled in a form about their experience. As we could not finish the first workshop (W1), we considered only the data collected from the 14 teachers who participated in W2 and W3[11]. The first was a Likert scale question about their satisfaction in participating in the workshop. All participants indicated their satisfaction in participating – Seven answered that they were *"satisfied"* and the other seven *"very satisfied"*. In their comments, four participants mentioned that although satisfied, they should have had more time to do it; one participant said *"excellent, but would need more time to refine properly,"* and another commented about the level of detail they needed to learn: *"very good, but requires a lot of attention in the steps, too many details"*.

The second question was related to the teacher's knowledge about the development of digital games. Five answered that they had been exposed to some information in the past but needed help, and nine participants said they had never done this kind of activity, but with help, they had been able to finish. In other words, all participants needed help to finish the tutorial, even those with some experience with digital games. According to the participants, the time was too short

[10]The quotes were translated by the authors to English. The participants' original statements were in Portuguese, their first language. In Table A, we present both the translation and the original comment in Portuguese.

[11]Form available at `http://tiny.cc/ahpevz`. Accessed on 08 Apr. 2024

for their first use as they were unfamiliar with many concepts and needed to learn them. Nonetheless, they were satisfied with the experience.

When asked about the difficulties in creating the game, thirteen participants answered the option *"Medium, but I could understand and execute the activities."* Only one participant answered *"Complicated, too many steps. I almost did not finish."* We also asked how they would characterize their learning in creating the game. All participants answered that they learned how to do it but would need help to do it again. Our fifth question was about the participant's opinions regarding the cost, work, and feasibility for a teacher to create a game using that platform. Four people answered *"I could create the game without any problems"*, eight participants answered *"I would create the game if I had time and help"*, one teacher answered that she would consider creating a game, but she would take into account the high cost of work and time. Based on these answers, we conclude that most participants felt confident they could create a game, but most of them (10 out of 14) expressed concerns about the time and support they would have in doing so.

Considering the main difficulties and benefits of the workshop, the teachers considered the possibility of creating a personalized game as the most significant benefit. Teachers mentioned that creating games as activities for their students would benefit their routine with them. Especially for special education (students with disabilities, global development disorders, as well as gifted students or those with high abilities) and new knowledge that could be used in the classroom.

They mentioned the tool's specificities and programming logic as the main difficulties. To illustrate these difficulties, we present two participants' statements: *"The workshop was great, but I experienced difficulties regarding the program used."* and *"The codes and reasoning of programming logic, the fact that I did not know the reason why each item was used"*.

About the workshop's format, six participants said they would be willing to participate in other workshops focused on different platforms, as they liked the theme. Five said they would use the same platform to create different games. Two people said they would consider doing another workshop with a different approach. These results show that teachers are willing to participate in this activity because they can learn and apply new things in the classroom. It is worth noting that several of the W2 teachers work with special education, and in the workshop, they commented that they commonly use games as a support activity.

Thus, for future editions of the workshop, we could make adaptations to better suit the teachers' time and needs. They expressed the need for the workshop to be longer (more time and more sessions) for them to be able to appropriate this technology. We also believe it would be important for them to have some knowledge about game design, mechanics, and testing other tools and games.

During the workshop, our observation and analysis allowed us to better understand aspects that were easy for teachers, as well as their main challenges. Although previous experiences with other tools allowed them to understand how to interact with the system easily, they experienced some usability problems. Notwithstanding, the main challenges were associated with understanding and using GDevelop constructs necessary to create a game [Souza and Prates, 2021]. In the next sections, we describe these findings in more detail.

4.2 Ease in Use

We found that teachers with more technology experience quickly started using GDevelop. They had fewer doubts and could configure the system even before the instructor explained the task and the steps required (described in the material) because they already understood it. The teachers noticed the impact of previous experiences, as verbalized by P1 (W3) *"I think she's had a few lessons before (laughs)"*.

The teachers supported each other by collaborating on tasks and troubleshooting errors. For example, in W2, one teacher discovered how to add text to a text object and asked if she could proceed. In another situation in W2, P2 said to another participant *'Drag the play button and the exit button, click and drag, no! Not on the picture, click on the play button."*. In W3, P3 had doubts about how to visualize the next scene and said *"Where's mine?"* P4 then helped her *"Hey P3, go back, here, click here again."* P3 understood and asked P4 new questions: *"Got it. What happened here?"*

Positioning objects on the screen was straightforward for the teachers as they interacted through direct manipulation. For example, P3 said in W3 *"Uuuh, it's just like Canva! (excited)"*. Thus, tasks related to dragging objects were easy for them to understand and perform. However, they did not always have a "sense of aesthetics" when positioning elements, resulting in misaligned buttons and unexpected screen placement.

Testing the game was also a straightforward process for the teachers as it was always easily accessible, with only a few uncertainties arising when they had not closed the test window. The teachers inquired about the feasibility of providing a game link for students' access. They expressed curiosity about acquiring graphic resources, demonstrating their interest in the topic despite the associated challenges.

4.3 Challenges

The most significant difficulty encountered by the teachers was understanding the necessary constructs to develop a game in GDevelop presented in the tutorial (object, scene, and events) [Souza and Prates, 2021]. Below, we briefly introduce each construct and describe the challenges the participants had related to each one.

4.3.1 Objects

Objects compose the scenes and can be of different types (sprite, text, particle emitter, and others), so background images, characters, and texts can be added to the scene by inserting objects. Depending on its type, the object has certain characteristics; for example, a sprite can represent characters, background images, and buttons because the user can introduce images and behaviors to it. The text object, in turn, makes it possible to introduce text that can have its appearance configured.

When using the objects to compose the scenes, the participants had doubts about naming these objects, always asking what name to insert. Several times they ended up using names that were non-intuitive or not directly related to the meaning of the object (e.g. "DIGITALGAME" as the name of the object representing a button); or they added spaces and special characters, which the system did not accept as part of an object's name. Moreover, whenever they added new objects to the scenes, they asked themselves if this was the correct procedure. This type of doubt made us realize that the teachers had difficulties understanding that the objects could represent "anything" in the scene (e.g., button and background), as was evident in W1 in statements by a participant questioning the creation of a button *"But to put a button... is this really how you do it?"*, indicating that she did not understand why she was adding an object to represent a button. The process of adding an animation (the term used by the GDevelop tool to add an image) to a sprite object constantly generated doubts; the term "animation" did not seem to be the best one for the teachers, perhaps because they did not associate it directly to a static image.

4.3.2 Scenes

Scenes can be considered the phases of a game in GDevelop, in which the user configures the game's functioning (logic) and layout (visual elements). Scene configuration involves two steps: adding the objects to the scene and configuring the event related to the objects. Most teachers considered adding and positioning the objects in the interface easy, as mentioned in the previous section. On the other hand, setting up the events was considered difficult for most of them.

When creating or opening a scene, GDevelop opens two tabs (like a web browser), one with the "scene name" (where the objects are configured – the visual part) and the other with the "scene name (events)" (where the events are configured – the logical part). Figure 4 shows the GDevelop interface; the tabs at the top indicate the opened scenes ("MainMenu" and "Level1"). Note that each scene is represented by two tabs, the name of the scene and the name of the scene followed by the word "(Events)", as seen in Figure 4.

Participants were constantly confused about the tab in which each action should be performed. Finding the scenes was also tricky for several teachers. They often asked where the scenes – which had to be accessed via the "project manager" menu – were. They also had difficulties regarding other actions related to creating or saving a scene. For instance, P1 expressed her doubts on how to save a scene: *"Okay, what do I do now? I save it (the scene)?"* The researcher explained that all she had to do was click anywhere outside of the text box, and the scene would be saved. Another situation from W1 illustrated the difficulties in understanding actions involving scenes. One of the teachers asked *"Do I need to create a new scene? I just clicked on it, and it just popped up"*, so the researcher explained how to do it, and another teacher then said *"Uuh I have already created a lot of scenes without realizing it (laughs)*."

They also had difficulties in naming scenes, as they had with objects. For example, in W1, P2 asked, *"And when renaming, do I put the name of the game, Researcher?"*. The researcher told her that they could choose any name but should always try to put a name that referred to the scene's purpose, such as "start", "initial", so it would be easy to remember. One possible reason for this difficulty was that GDevelop always creates a new scene with the name "untitled scene". The rules for renaming it (i.e., they could not use special characters – ç and accents – but they could use spaces) were unclear to them and different from the rules for naming objects.

Furthermore, in the workshop, to create the second "question scene", we duplicated a scene and altered it, renamed it, and re-configured it to get a different function and create a new scene. However, although renaming and duplicating documents are part of this audience's experiences with technology, they needed help on the platform. For example, in W3, P3 asked *"Do I have to put the correct answer in the same option?"*, indicating she did not understand that she could change everything on the copied scene.

4.3.3 Events

Events represent occurrences in the game that can trigger some action or feedback in elements or scenes. So they introduce logic into games. When configuring events, participants found it difficult to understand the decomposition level required to define an event. For example, to configure the event associated with pressing a button, they had to add an event with two conditions *"when the mouse cursor is over the object"* and *"when you release the left mouse button*", and the action *"change to the scene (scene name)*". Figure 4 shows the configuration of the "Exit" and "Play" buttons, each of which leads to a different action, exiting the game and changing to the scene of the first question of the quiz, respectively. The condition is on the left side of the screen, and the associated action is on the right side. Participants had difficulties understanding that the action of *"releasing the left mouse button"* meant clicking the button since the player would first have to press the button and then release it. During the configuration of events, participants often asked what they had to do and how to do it, indicating they had not understood how to express events in terms of conditions and related actions. This could be seen in statements such as when P1 asks during W1 *"But is it a condition or an action?"*, just after the researcher explained that they had to add a condition to the event to configure a button.

The conditions and actions are configured by navigating through a menu system. However, carrying out this configuration was considered somewhat complicated by most participants because they perceived the process as involving many steps and believed they would not remember them when trying to create a game by themselves. In W3, several comments illustrated this difficulty, such as P6's *"There are so many steps you have to take, you can forget them."*, P3's *"It is complicated, but it is good. It is a lot of information, but it is good."* and P1 *"Very interesting, we needed more time... I think we have to keep trying to do it..."*. These quotes demonstrate that the teachers felt they would need other sessions because the 2 two-hour workshop was seen as too short for them, as came up in several comments such as P4's in W1 *"Should have more time, right?* In W3, after some explanations and examples of the use of events, the researcher asked

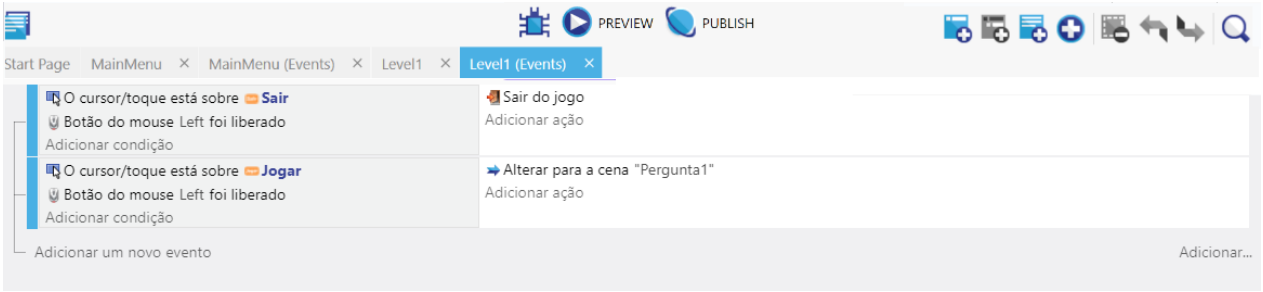

Figure 4. Events tab in GDevelop.

them if they understood how the conditions worked in the events. P5 quickly replied *"No way!"* and P1 tried to help by saying *"it's for you to create the game."*. Even though P1 explained that the events were necessary to generate the game, she was not able to explain how they worked.

The configuration of actions and conditions required around 4 to 6 steps, but the configuration for modifying the text of an object that represents a variable required 12 steps, which the teachers argued was very difficult to remember. For instance, the task to create an object that counted points in the game consisted of: (1) creating an event in the "end" scene, (2) adding an action, (3) selecting the "dots" text object, (4) clicking on "modify text", (5) setting the modification sign to "= (set as)", (6) clicking on the value "∑ ABC" button, (7) clicking on "variables", (8) then on "global variables", (9) clicking on "value of a global variable", (10) selecting the variable "points", (11) clicking on "apply", and (12) clicking on "ok". Usually, the event configuration is shorter, but this is a case where the participants found it too long to remember.

Duplicating events was complex for most teachers because they did not understand the boundaries of the events and what each one represented within the scene. When asking the teachers to duplicate an event (configuring a button) to reduce the effort of making similar settings, we observed that the teachers changed the original event instead of the copy, added other conditions to the original event, or made several copies instead of one. Even though participants were used to performing "copy and paste" in other contexts, they needed help to perform them for the Events. To illustrate it, in W1, P4 said to the researcher *"Oh Lord! I can´t follow properly your instructions, stop, stop, go back, explain again!"*, the researcher explained the copy and paste action again and said *"I have two events that are the same, see?"* and then P2 *"I have ten teacher"*, P5 said *"Where should we copy and paste it?"* and the researcher explained that by clicking "ctrl+v", the program automatically copies the event below the previous one, and helped P2 to delete the repeated events.

4.3.4 GDevelop Usability Problems

We identified some features and design decisions in GDevelop that generated doubts in the participants. Scenes are inaccessible from the interface unless the user opens the project management menu. When a scene is renamed, it is automatically closed, confusing the teachers who wondered what had happened. For instance, a participant said: *"I renamed it, and it disappeared from the screen!"*, showing she did not understand what had happened. In this case, the action required was to click on the scene name in the project manager to reopen it.

Also, when configuring an action, the need to indicate the following scene confused participants. Besides, writing the name of a scene (before even creating the scene) between double quotation marks led them to errors, as they misused the quotation marks. For instance, they used single quotation marks or did not close the quotation marks. In this case, the system indicated the error by turning the text red, but they constantly forgot the reasons that led to the error and did not understand how to configure a call for another scene.

Teachers also confused the state of the system when testing the game because when the user does not close the execution window, the "view" button on the main interface has its text changed to "update"; this difficulty was easily overcome, although it happened several times in the three workshops. They could not find the window either because when "updating" the test, the pop-up window does not overlap the GDevelop editing window, requiring the user to look for it in the taskbar. Some teachers were unsure about the type of system they were using, and some of them did not know whether it was a website or a desktop application. At W1, one teacher asked, *"Is it an app? I just left here, and I can't find it anymore"*. Another asked what kind of program GDevelop was. Then the researcher explained that they were using the software's desktop version but could use it online.

In addition, the division of scenes into "visual part" and "logical part" (events) confused the participants several times, as they often thought that the event linked to an object should be configured inside the object. The rules regarding acceptable names for objects and scenes also generated many doubts due to the participants' lack of experience using this type of tool, as they often wanted to name scenes and objects by writing in Portuguese (with spaces and special characters). Even navigating between the scene tabs generated some doubt, as the teachers were unsure if closing the tab would delete the scene.

Observing the participants' behavior, we noticed that many of their doubts were related to the fear of committing errors or of exploring the tool; they were always trying to confirm what had to be done to do it correctly rather than understanding the reason for doing something. Their difficulties might be due to the lack of knowledge about game development and game design or even low digital literacy. In addition to the difficulties related to using the tool, we noticed that the teachers had difficulty understanding the logic of game construction. For example, in W3, after duplicating

a question scene to reduce rework, P3 asked: *"Is it question 1 or question 2 that I have to change?"*. The researcher explained that it was question 2, but as the teacher was already changing the question 1 scene, there was no problem. She could do that and then change the order in which the questions appear. The teacher seemed to understand, and the researcher told her to update the answers to the new question. Then P4 and P1 also expressed doubts regarding the same task. P4 asked *"So do I ask another question?"*, the researcher said yes, and then P1 said that she did not understand the task *"I did not understand this last part"* exposing the difficulty in understanding the task.

5 Discussion and Implications

In this section, we discuss the findings of our study and propose an initial set of design recommendations for tools facilitating the development of educational games by elementary school teachers.

5.1 Discussion of our Findings

While GDevelop is designed for non-expert users, participants who had experience in using technology to mediate teaching (during the pandemic) faced challenges in utilizing the system during a guided tutorial, in which they were presented with each instruction step-by-step. Subsequently, participants expressed they expected they would have difficulties to use the system by themselves after the workshop. They felt they would need additional sessions to completely understand the terms and concepts introduced during the workshop and grasp the tool's functionalities.

This finding underscores the necessity for providing teachers with more training in technology to enhance their abilities to integrate new technologies into their classroom activities. Additionally, there is a need to explore the development of environments explicitly tailored for this audience, more closely aligning concepts and functionalities to their daily experiences.

As an initial step in fostering teachers' digital literacy, it would be beneficial to provide training based on the "Guidelines for Teaching Computing in Basic Education" [SBC, 2019]. Our observation during teacher assistance has revealed challenges primarily associated with the dimensions of Computational Thinking and the Digital World. Computational thinking skills, as outlined by SBC [2019], encompasses the ability to comprehend, define, model, compare, systematically solve, automate, and analyze problems through algorithmic construction. Whereas digital world skills rest on three foundational pillars: coding, processing, and distribution. These pillars aid in comprehending the digital realm and appropriating processes occurring in both digital and real-world contexts. Becoming adept at understanding and critiquing trends positions educators as active participants in this scenario. Proficiency in these axes equips teachers to navigate the Digital Culture, fostering interdisciplinary connections in computing. This, in turn, enables fluency in applying computational knowledge to articulate solutions and cultural expressions in a contextualized and critical manner [SBC, 2019].

Since elementary school students are expected to acquire skills aligned with the specified guidelines, teachers must comprehend and use these skills. Many of these skills are intended to be acquired across subjects already embedded in the curriculum, such as languages, mathematics, and sciences [SBC, 2019]. Consequently, initiatives to train teachers to meet the evolving requirements of basic education are indispensable. Proficiency in the three pivotal axes — digital culture, computational thinking, and the digital world — can empower teachers to leverage diverse technological resources to support their instructional practices effectively.

Considering teachers from rural or urban school settings, we did not notice differences in their comprehension and utilization of the platform. Common challenges and feedback regarding tool utilization were identified in both contexts. Notably, educators with a predisposition towards technology or a background in computer science, including those who had taken programming courses at the university level or pursued technical courses in information technology, displayed a greater willingness to explore the platform. Participants who had any knowledge (even basic) of computing and programming logic found it easier to use the system, although none of the participants were familiar with GDevelop. We noticed these participants were more proactive in exploring the tool´s settings, even before the researcher explained the next steps, and assisted their peers.

It is important to highlight that building games is in itself a challenging task in addition to technology-related difficulties. The teachers had not built digital games before, so thinking about the logical aspects of game design is not a common skill for this audience. According to the study presented by do Prado *et al*. [2020], exposing teachers to different types of games can be useful to help them when designing their own game.

To better understand aspects related to teachers creating digital educational games in more depth, we carried out another study (still in the data analysis phase). We conducted a course on digital game development for an audience of mostly in-service elementary school teachers. In this course, participants were introduced to game concepts, such as mechanics and dynamics, and the implementation of digital educational games. This study reinforces the idea that technology, although a challenge, is not the only difficulty faced since the lack of familiarity with different game genres and other elements involving game design (e.g. developing the logic and game score) and lack of knowledge in computational thinking were seen as major challenges.

As an implication of this study, we advocate for implementing in-service teacher training programs encompassing competencies aligned with the Guidelines for Teaching Computing in Basic Education formulated by the Brazilian Computer Society (SBC) [SBC, 2019] and subjects related to developing educational digital games. Furthermore, academic degree programs designed to prepare teachers should incorporate courses dedicated to cultivating these skills among pre-service teachers. It should also be a training course available for public school teachers.

5.2 Design Recommendations

Based on our findings, we have defined an **initial** set of design recommendations that can be useful in (re)designing platforms for the development of educational games by elementary school teachers. Next, we present each recommendation and explain the findings that motivated it:

- **Define more specific types of objects:** The teachers questioned why they always used one type of object for "everything" (i.e sprite). Thus, defining different objects at the interface level that better convey what they represent, such as buttons, characters, background images, text, and sound effects, seems to be a more straightforward way of presenting the elements that can compose games for this audience. The different types of objects would increase the number of elements in the interface to be learned and perhaps even generate some limitations on the expressiveness of the language offered by GDevelop. However, being closer to the abstractions teachers understand may be a benefit worth the cost.
- **Provide a step-by-step support to create the constructs:** This analysis identified the need for a step-by-step approach to support two constructs, objects and scenes. The participants often forgot to name the objects (which were given a standard name that they then had to change) or confused the step by step of adding the animation (i.e. image) to it. Therefore, presenting the necessary actions organized as a short set of steps (i.e. an interface wizard) could make it clearer for this audience. For instance, a wizard to create the objects could present each step sequentially: (i) define a name; (ii) define an image or animations; and (iii) define behaviors, which could make it easier for the teachers. It could also allow teachers to ask for more support at each step (e.g. understanding what the name was used for, or the rules that govern how to define a name). Participants were also often confused when creating the events related to the objects. They understood that events were related to the objects, and they mentioned they had expected it to be a configuration within an object and not as another construct in the interface. Navigating among scenes within the system was also confusing for them. Especially between the visual content and game logic content tabs. It could be interesting to offer a navigation that allowed them to determine all the scene settings sequentially.
- **Rules for naming constructs:** The participants had many difficulties in understanding there were rules for naming objects and scenes and what the rules were. Furthermore, the rules were not the same for both constructs. Thus, instead of automatically creating a name that the user could change, it might be easier if the system required users always to enter a name to create a construct. It would make it a mandatory action (as opposed to optional) but would guarantee that the user selected a name that might be used later. Furthermore, the system should clarify the rules for naming variables when an invalid name is proposed or available by demand through contextual help.
- **Configuration levels:** The number of steps and settings necessary to configure constructs was often confusing for the participants, who needed help understanding. For instance, even when creating a button, which could be considered a "simple task" participants had doubts. Thus, it would be interesting to consider having configuration levels the user could select from. The more basic level would be simpler and more limited, offering predefined settings. The more advanced level would present the full-fledged configuration settings and allow greater flexibility. The different configuration levels could be useful for users to learn the system and their concepts more gradually instead of having to learn it all the first time they are using it.
- **Provide a repository of resources:** During the workshop, the resources required (i.e. images, sounds, etc) to create the game developed were provided to participants. It was very useful, and several teachers were interested in learning how they could find free resources that were ready for use. For example, in W1, P1 asked about the resources *"The graphic design for these screens, can I get them ready for use off the internet or can I create them here?"* These resources are essential to the development of a game, and it might be time-consuming looking for assets available for use aligned with the game´s content. Thus, providing a repository of resources would make it much easier for teachers to develop games.
- **Consistent multilingual support:** In this study, the teachers spoke Portuguese (their first language). Those who tried to explore the tutorial videos on the platform saw that they were in English and gave up watching them because they did not know the language. To illustrate, in W1, when P4 faced the videos in English, she said *"Oh it's all in English... I'm not even going to try"*. Multilingual approaches must, therefore, also have support material in the languages supported by the tool.

As we reflected upon the lessons learned from our work, we recognized that providing an extensive initial tour of the tool was ineffective, as participants tended to forget the details afterward. Consequently, after W1, we modified our workshop approach to cater to each interaction. Furthermore, workshops with fewer participants or with more assistants would be ideas to effectively address the needs and doubts of all attendees within a short time, such as in the case of our workshop. We found that participants faced many challenges performing the activities, even with our guided tutorial. Thus, as mentioned in our recommendations, it would be relevant to create strategies that allow users to gradually learn and advance in the tasks necessary to create a game. It is becoming crucial for both pre-service and in-service teachers to engage in activities that enhance their digital literacy skills. A game creation tool could also support them in achieving these skills by creating a more gradual approach to creating the game.

6 Threats to Validity

Our study is limited by the number of workshops conducted in schools selected through a "snowball" approach. We conducted 3 workshops in the cities of Porteirinha (W1 and W2) and Nova Porteirinha (W3) in Minas Gerais. Unfortunately, we did not finalize the tutorial in W1, preventing the application of the questionnaire about these teachers' experiences in participating in the workshop. We acknowledge that this sample only encompasses a very small part of the spectrum of diversity across Brazilian educational contexts. Nevertheless, the goal was to conduct a qualitative in-depth approach which allowed us to identify the challenges experienced by the participants. It is worth noting that there was a convergence of the challenges identified in the 3 workshops.

Another limitation was the workshops' short duration period. Each workshop was only 2 hours long due to the time allocated by the State for teachers to stay at school and dedicate to planning or training. Thus, we could only explore part of the system and select a few constructs to work with the participants in developing the game. A longer workshop or course would allow for a more thorough exploration of the system and its constructs and collect more data on which of the participants' challenges were overcome or not , and the strategies they used to do so.

Furthermore, only one researcher conducted the workshops, and she was responsible for conducting the workshop, assisting participants, and taking notes (after each workshop) of any observations of interest. If we had an additional tutor, we could have provided better assistance to the participants, might have been able to complete all the workshops, and have more than one observation perspective. Another limitation of our study is that only the first author performed all of the data analysis. As a mitigation strategy, the results were discussed with a second and more experienced author.

7 Conclusions and Final Remarks

This analysis was part of a study on the overview on Brazilian elementary school teachers regarding the use of educational games and technological resources. Workshops were conducted as part of this study to elicit insights from teachers regarding their experiences with a game development tool. During these workshops, the GDevelop tool was introduced to the participants, accompanied by an in-person tutorial illustrating the creation of a simple quiz-type game. This approach allowed us to analyze the participants' experiences, as well as the actions that were easy or that posed challenges for them in developing digital educational games.

Conducting digital-literacy-focused activities involving digital tools to support elementary school education represents a means of augmenting the technological proficiency of this demographic, a requirement nowadays. The study identified challenges, encompassing the comprehension of system operations, the rationale behind tasks, object configuration, event programming, and understanding concepts such as events, conditions, and actions. These findings elucidate the obstacles encountered by educators in this domain. Given this comprehension, it is conceivable to envisage courses designed to equip teachers with the required skills to navigate and effectively use such tools. These courses need to include an introduction to the relevant Computational Thinking and the Digital World concepts, given the presence of specific abstractions inherent to the field of computing, distinct from other domains.

Some systems offer games and interactive activities that can be easily configured by allowing the content to be defined through templates (e.g., Genially[12]). Although these systems are characterized by their simplicity, they often limit the scope of user-created or customized content. As a result, they often prevent users from developing more intricate and authorial concepts tailored to their specific educational requirements.

In the next steps of our research, we intend to conduct longer teacher training activities using environments such as GDevelop and other educational game development tools. In this direction, we have prepared and conducted a course with a target audience similar to the participants in this study. The course was a 30-hour course, with one class a week conducted throughout 3 months, exploring game creation using GDevelop. We are now analyzing the data collected in this course, which will be useful to consolidate and complement the findings of this work. We also intend to explore alternative end-user game development tools in future work. Furthermore, a future step involves establishing which requirements and skills associated with digital literacy [SBC, 2019] would be necessary for teachers to learn to develop educational games in game-authoring tools.

Declarations

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Authors' Contributions

The first author contributed by choosing the tool used, building the tutorial, building the workshop script, carrying out the pilot test and the workshops with the teachers, and then analyzing the data. The second author participated in the decisions and discussions regarding the study conducted, its preparation, and materials, as well as in writing and reviewing the paper.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The tutorial generated during the current study is available at `http://tiny.cc/jfd7vz`. The Consent Form presented to teachers is

[12] `https://genial.ly/pt-br/`. Accessed on 03 Apr. 2024

available at `http://tiny.cc/9gpevz`. The Consent form that principals presented to school principals is available at `http://tiny.cc/agpevz`. The questionnaire teachers filled in at the end of the workshop is available at `http://tiny.cc/ahpevz`. All the materials are in Portuguese, the language used by the target public.

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A Appendix

In this appendix, we present Table 1 containing the participants' quotes cited in the article. The first column presents their translation by authors to English, the second column the original quote in Portuguese, and the third column the page in which it appears in the paper.

Speech in English	Speech in Portuguese	Page
The workshop was great, but I felt much difficulty regarding the program used.	A oficina é ótima, mas senti muita dificuldade em relação ao programa a ser usado.	6
The codes and reasoning of programming logic, the fact that I did not know the reason why each item was used.	Os códigos e raciocínios da lógica de programação, o fato de não conhecer o porque de cada item para utilização.	6
I think she's had a few lessons before (laughs)	Acho que ela teve umas aulinhas antes (risos)	6
Drag the play button and the exit button, click and drag, no! Not on the picture, click on the play button.	Arrasta o botão jogar e o sair, clica e arrasta, não! Não na imagem, clica no botão jogar.	6
Where's mine?	Cadê a minha?	6
Hey P3, go back, here, click here again.	Oh P3, volta lá, aqui ó, clica aqui de novo.	6
Got it. What happened here?	Ah tá. O que que aconteceu aqui?	6
Uuuh it's just like Canva! (excited)	Uuuh é igual o Canva! (animada)	6
But to put a button... Is this really how you do it?	Mas para colocar um botão... É assim mesmo?	7
And when renaming, do I put the name of the game, Researcher?	E no renomear, eu coloco o nome do jogo, Pesquisadora?	7
Okay, what do I do now? I save it (the scene)?	Tá e o que eu faço agora, salvo?	7
Do I need to create a new scene? I just clicked on it and it just popped up	É pra criar nova cena? Eu só tô clicando e só tá aparecendo	7
Uuh I have already created a lot of scenes without realizing it (laughs).	Uuh eu já fiz um tanto de cena sem saber (risos)	7
Do I have to put the correct answer in the same option?	Eu tenho que colocar a resposta certa na mesma letra?	7
But is it a condition or an action?	Mas é condição ou ação?	7
There are so many steps you have to take, you can forget them.	É muito passo a passo que tem que tá, que pode esquecer.	7
It is complicated, but it is good. It is a lot of information, but it is good.	É complicado, mas é bom. É muita informação, mas é bom.	7
Very interesting, we needed more time... I think we have to keep trying to do it...	Muito interessante, a gente precisava de mais tempo... Eu acho que a gente tem que ficar tentando fazer...	7
Should have more time, right?	Devia ter mais tempo, né?	7
No way!	Num dá não!	8
It's for you to create the game.	É pra você gerar pra criar o jogo.	8
Oh Lord! I can´t follow properly your instructions, stop, stop, go back, explain again!	Senhor da glória! Eu não tô conseguindo acompanhar direito, péra ainda, péra ainda, volta aí, explica de novo!	8
I have two events that are the same, see?	Eu tenho 2 eventos iguais, estão vendo?	8
I have ten teacher	Eu tenho 10 professora	8
Where should we copy and paste it?	É pra copiar e colar onde?	8
I renamed it, and it disappeared from the screen!	Eu renomeei e sumiu da tela!	8
Is it an app? I just left here and I can't find it anymore	Ele é um aplicativo? Eu saí aqui e não tô achando mais	8
Is it question 1 or question 2 that I have to change?	É pergunta 1 ou pergunta 2 que eu tenho que mudar?	9
So do I ask another question?	Então eu faço outra pergunta?	9
I did not understand that last part	Eu não entendi essa última parte	9
The graphic design for these screens, can I get them ready to use of the internet or can I build them here?	Essas telinhas? Eu posso pegar pronta da internet ou aqui dá pra montar?	10
Oh it's all in English... I'm not even going to try	Ah, tá tudo em inglês… Vou nem tentar	10

Table 1. Participants' quotes included in the article. The authors translated the original quotes in Portuguese (right column) into English.