

Probability teaching and learning: students' first contact with the digital game *Batalha com Dados*

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Abstract: In this investigation, we present part of a research carried out within the scope of the Professional Master's Degree in Education and Teaching, at the Faculty of Education of the Federal University of Minas Gerais. The research aims to analyze the effectiveness of using a digital game in teaching Probability concepts to students in the 5th grade of Elementary School. It was carried out from a qualitative perspective, with the aim of valuing the description, dialogues, and experiences of students. This article aims to describe and analyze the students' first contact with the game *Batalha com Dados*. We conclude that this game provides the opportunity for students to work collaboratively and stimulate the development of social skills, such as communication and cooperation. While students were interacting, they could build together a deeper understanding of the concepts of Probability. Therefore, the *Batalha com Dados* should be used as a complementary resource to teaching.

Keywords: Mathematics Education. Statistical Education. Probability Teaching. Elementary School. Digital Probability Game.

Enseñanza y aprendizaje de Probabilidad: el primer contacto de los estudiantes con el juego digital *Batalha com Dados*

Resumen: En este trabajo presentamos parte de una investigación realizada en el ámbito de la Maestría Profesional en Educación y Docencia, de la Facultad de Educación de la Universidad Federal de Minas Gerais. La investigación tuvo como objetivo analizar la efectividad del uso de un juego digital en la enseñanza de conceptos de Probabilidad a estudiantes del 5º grado de la Escuela Primaria, y se realizó desde una perspectiva cualitativa, con el objetivo de valorar la descripción, diálogos y experiencias de los estudiantes. En este artículo, nuestro objetivo fue describir y analizar el primer contacto de los estudiantes con el juego *Batalha com Dados*. Concluimos que este juego brinda la oportunidad a los estudiantes de trabajar de manera colaborativa y fomenta el desarrollo de habilidades sociales, como la comunicación y la cooperación. Al interactuar, los estudiantes pueden construir juntos una comprensión más profunda de los conceptos de Probabilidad. Por lo tanto, el juego debe ser utilizado como un recurso complementario a la enseñanza.

Palabras clave: Educación Matemática. Educación Estadística. Enseñanza de Probabilidad. Primeros Años de la Escuela Primaria. Juego Digital de Probabilidad.

Ensino e aprendizagem de Probabilidade: primeiro contato dos estudantes com o jogo digital *Batalha com Dados*

Resumo: Neste trabalho, apresentamos parte de uma pesquisa realizada no âmbito do Mestrado

Profissional em Educação e Docência, da Faculdade de Educação da Universidade Federal de Minas Gerais. A pesquisa teve como objetivo analisar a efetividade do uso de um jogo digital no ensino de conceitos de Probabilidade para estudantes do 5º ano do Ensino Fundamental, e foi realizada numa perspectiva qualitativa, com o intuito de valorizar a descrição, os diálogos e as experiências dos estudantes. Neste artigo, nosso objetivo foi descrever e analisar o primeiro contato dos estudantes com o jogo *Batalha com Dados*. Concluímos que este jogo proporciona a oportunidade de os estudantes trabalharem de forma colaborativa e estimula o desenvolvimento de habilidades sociais, como comunicação e cooperação. Dessa forma, ao interagirem, os estudantes podem construir juntos um entendimento mais profundo sobre os conceitos de Probabilidade e, portanto, o jogo deve ser utilizado como um recurso complementar ao ensino.

Palavras-chave: Educação Matemática. Educação Estatística. Ensino de Probabilidade. Anos Iniciais. Jogo Digital de Probabilidade.

1 Introduction

Throughout the teaching practice, while working in the classroom of the Public School System of Minas Gerais since 2019, the first author was able to observe the students' difficulties regarding the concepts of Statistics and Probability. There was a greater difficulty in reading and interpreting data, whether related to graphs and tables or the use of probability in everyday situations. Furthermore, the difficulty in probabilistic reasoning by students became evident. When the topic is not developed from the Early Years of Elementary School, it can eventually become a bigger problem, affecting not only the students' academic life but also their personal life.

Thus, this gave rise to an interest in researching the learning of Probability in the 5th grade of Elementary School by using a digital game. This research was carried out from 2021 to 2023, within the scope of the Professional Master's Program in Education and Teaching at the Faculty of Education of the Federal University of Minas Gerais¹. In this article, we will focus on describing and analyzing the first encounter of 5th grade students with the digital game *Batalha com Dados*, which was developed and presented as an Educational Resource during the professional master's degree course. Additionally, we provide brief discussions on the teaching of Probability and the use of games in the classroom, as well as we describe the methodological design of the research.

2 Theoretical framework

The teaching of Statistics and Probability was included as a topic in the national curriculum of Elementary School in many countries during the 1980s. However, in Brazil, this concern only arose in 1997, with the publication of the National Curriculum Parameters [*Parâmetros Curriculares Nacionais — PCN*]. In 2017, with the publication of the Common National Curriculum Base [*Base Nacional Comum Curricular — BNCC*], the current reference for the elaboration of school curricula throughout the country was obtained. In this document, in the area of Mathematics and its Technologies, the referred contents began to appear in the thematic unit called *Probability and Statistics*.

From this insertion, it was advocated that statistical and probabilistic concepts should be introduced into the school reality from the Early Years, in line with Avelar and Conti (2022), when the authors affirm that it is

¹ This article is an excerpt from a master's thesis defended in the Postgraduate Program in Education and Teaching at the Federal University of Minas Gerais. It was written by the first author and supervised by the second author.

necessary for these students to grow up developing the skills required to become critical adults, with the ability to read, understand, and comprehend graphs, data, and statistical analyses. In addition to developing the power to make decisions, knowing how to use probabilistic concepts in our daily lives is essential for us to make more accurate analyses in our decision-making and, therefore, to be able to make useful predictions in everyday events (Avelar & Conti, 2022, p. 1802).

We believe it is possible to explore other teaching resources with the aim of sparking students' interest in probabilistic content and developing Probabilistic Literacy. According to Gal (2005), Probabilistic Literacy is necessary in adulthood because "knowledge of probability is relevant mainly for functioning in personal, community, and social domains, in which situations require interpretation of probabilistic statements, generation of probability judgments, or decision-making" (Gal, 2005, p. 49).

Gal (2005) presents what he calls a *Probabilistic Literacy model* (Table 1), in which he indicates the elements of knowledge and the elements of disposition with the aim of assisting in the construction of citizens' probabilistic thinking:

Table 1: Probabilistic Literacy model presented by Gal (2005)

<i>Knowledge elements</i> 1. Great ideas: Variation, randomness, independence, predictability/uncertainty. 2. Probability calculation: Ways to find or estimate the probability of events. 3. Language: Terms and methods used to communicate about chance. 4. Context: Understanding the role and implications of probabilistic issues and messages in various contexts and in personal and public discourse. 5. Critical issues: Questions for reflection when dealing with probabilities. <i>Disposition elements</i> 1. Critical posture. 2. Beliefs and attitudes. 3. Personal feelings regarding uncertainty and risk (risk aversion, for example).

Source: Gal (2005, p. 51)

In Table 1, the author presents the elements of disposition separately from the elements of knowledge with the aim of providing a clearer presentation. However, it is important to emphasize that, as they are developed, it is crucial that all these elements interact with each other to make it possible to achieve the development of Probabilistic Literacy.

The major concepts, especially those of randomness, independence, and variation, according to Gal (2005), underpin students' ability to understand the representation, interpretation, and implication of probabilistic statements. The author argues that some of the big ideas can be expressed through mathematical symbols or statistical terms, but students "must understand the general abstract nature of these ideas only intuitively" (Gal, 2005, p. 52), since their essence cannot be conveyed through mathematical notations.

The second element of knowledge addresses probability calculation. At this point, it is expected that the student is familiar with methods for determining the probability of events, in order to "understand probabilistic statements made by others or to generate estimates about the probability of events and communicate with others about them" (Gal, 2005, p. 54).

According to the author, language is the third element of knowledge, and needs to be addressed in two distinct areas. The first area concerns abstract constructs, in which the student develops "familiarity with terms and phrases related to relevant abstract constructs" (Gal, 2005,

p. 55). In it, Gal (2005) indicates that the terms addressed in the big ideas, along with the terms chance, probability, and risk, are not easily understood, and can only be developed after a cumulative path. The second area of language, in turn, is dedicated to the various ways “of representing and talking about the probability of real events” (Gal, 2005, p. 55). Reflecting on real probabilities, it is expected that students become familiar with different quantitative mathematical representations and feel comfortable with these representations.

The author also argues that, to develop Probabilistic Literacy, people need to understand about probabilistic processes and communications in the world. In this sense, knowledge of context, which is the fourth element of knowledge, involves understanding “(a) what is the role or impact of chance and randomness in different events and processes and (b) what are the common areas or situations in which notions of chance and probability may arise in a person’s life” (Gal, 2005, p. 58).

The last element of knowledge, called critical questions, addresses the importance of formulating questions when facing problems involving “probability or certainty statements, or when it is necessary to generate a probabilistic estimate” (Gal, 2005, p. 59). Therefore, it is expected that students do not accept any probabilistic statement without critically analyzing it and that they ask the necessary questions to reach a well-founded conclusion.

The disposition elements are divided into three categories: critical stance, beliefs and attitudes, and personal feelings towards uncertainty and risk. According to Gal (2005), these elements play a fundamental role in how people think about probabilistic information and how they act in situations involving chance and uncertainty. Furthermore, it is important for people to be able to distinguish, when faced with a probabilistic situation, to what extent their perceptions are related to actual facts or based on beliefs, risk aversion, conservative thoughts, or overconfidence. According to Gal (2005), the development of knowledge elements and disposition elements, as presented in Table 1, through a coordinated and balanced guidance, leads to Probabilistic Literacy.

Under this perspective, we recommend that teachers adopt the Probabilistic Literacy model proposed by Gal (2005) in the development of their activities with students. This approach aims to provide students with the necessary skills to initiate the process of Probabilistic Literacy, enabling them to understand, interpret, and use probabilistic concepts in everyday situations. By promoting this proposal, it is hoped to enable students to deal critically with uncertainties and probabilities that arise in their lives, preparing them to make informed and reasoned decisions.

2.1 Games in education

According to the PCN (Brazil, 1997), the use of games is recognized as a pedagogical strategy for teaching Mathematics, as it promotes interaction, motivation, and meaningful learning for students. Games are seen as an opportunity to experience challenging situations, stimulating logical reasoning, problem-solving, and the development of mathematical strategies.

With the perspective that teachers use new strategies and methodologies, the BNCC (Brazil, 2017) encourages them to explore new activity possibilities. Among these strategies, the BNCC (Brazil, 2017), as it already happened with the PCN (Brazil, 1997), recommends the use of games with the aim of awakening students’ interest through a more enjoyable activity.

For Grando (2004), teachers often use games in the classroom without planning how to proceed after the activity, focusing only on enjoyment. Consequently, they fail to explore the possibilities arising from the game, preventing an evaluation of how much the game assisted in

teaching the content covered. When this occurs, it is believed that the game is being used spontaneously and, as a result, it presents “an end in itself, ‘the game for the game’s sake’, or aiming solely to prioritize motivational aspects” (Grando, 2004, p. 15). For the author, there is a lack of concern in encouraging students to engage in reflections, registers, and analyses of the actions performed in the game. Thus, the game is reduced to “understanding and compliance with the rules, with informal and spontaneous elaboration of strategies, and without much contribution to the teaching-learning process of Mathematics” (Grando, 2004, p. 15).

Aiming at providing opportunities that stimulate students’ development, Grando (2004) recommends the use of seven pedagogical moments that can assist the teacher in making the necessary pedagogical interventions when intentionally proposing a game in the classroom. The seven moments of the game are established by the author as:

1st Moment — Familiarization of students with the game materials: during this first moment, students become acquainted with the materials used in the game, establishing connections with other materials or games they already know. The teacher can assist students with simulations of possible moves, aiming to help them understand how the game works.

2nd Moment — Recognition of the rules: at this moment, students should dedicate themselves to recognizing and understanding the rules of the game. It is recommended to read the rules or have the teacher explain them to the students. For this moment, simulations of moves can also take place so that students identify regularities, absorbing the rules of the game.

3rd Moment — The *game for game’s sake*: playing to ensure the rules: during the third moment, students should make their first moves to understand and enforce the rules. Hence, there is a time dedicated to playing spontaneously in order to ensure that students recognize, understand, and comply with the rules of the game.

4th Moment — Verbal pedagogical intervention: after the completion of the previous steps, at this moment, the teacher conducts oral interventions aimed at questioning the students about their moves, leading them to reflect on and analyze their actions. This moment enables the understanding of the decisions made by the students to solve the proposed problem, as well as their relationship with the related mathematical knowledge.

5th Moment — Game registering: the type of registering to be performed will depend on the nature of the proposed game and the objectives the teacher aims to achieve with this activity. This registering can serve as support for the plays to be made or for understanding choices, leading students to comprehend and critically analyze the game’s actions. These registers help the teacher to get to know the students better.

6th Moment — Written intervention: at this moment, the teacher presents to the students the problematization of game situations. In this way, it is possible to address situations of the game that may or may not have been experienced. Similar to the previous moment, the generated registers provide the teacher with a greater understanding of their students’ thoughts.

7th Moment — Playing with *competence*: at this moment, the student has the opportunity to play and put into practice the learning acquired during the other moments. Thus, students are invited to play and apply the analyses made, executing the assimilated strategies.

The seven moments of the game represent “the definition of a possible and useful pedagogical work to be carried out” (Grando, 2004, p. 110). By following these moments, the teacher will be providing students with “conditions to reflect, communicate, argue, raise hypotheses, conjectures, and validate their analyses” (Luvison & Grando, 2018, p. 65).

Therefore, agreeing with what is advocated by Grando (2004), we believe that the use

of games can promote differentiated classes that assist in the exploration of strategy development. This will provide moments of individual and/or group reflections, aiming to contribute to an education that helps students become critical and reflective citizens. Consequently, by enabling learning and the development of Probabilistic Thinking (Gal, 2005) through innovative practices using technology, we decided to use the game *Travessia do Rio* as inspiration for creating the digital game *Batalha com Dados*².

3 Methodological design

This field research was conducted with 5th grade students from a municipal school in the metropolitan region of Belo Horizonte, through a qualitative approach, believing that this is “a research methodology that emphasizes description, induction, grounded theory, and the study of personal perceptions” (Bogdan & Biklen, 1994, p. 11). In this way, it was possible to describe and analyze the research conducted and its actions more effectively.

The fieldwork was conducted with three 5th-grade classes of Elementary School, each comprising 24, 25, and 26 students respectively, totaling 75 students. The sessions, all lasting 1 hour, were scheduled with the class teacher, and the students were informed about them in advance. The initial contact with the students occurred after their guardians signed the Free and Informed Consent Form (FICF). Therefore, there were eight sessions, held from 4th July to 3rd November, 2022. It is worth noting that all sessions took place with the three classes on the same days. The sessions always occurred in the school auditorium, which was previously set up to accommodate the students in pairs. Tablets were provided for use on the occasion.

With the aim of qualitatively describing, data production instruments such as video recordings of the sessions and accurate and truthful audio recordings of dialogues with students were utilized. Additionally, the database generated from the game and the field journals produced by the researcher were used. Furthermore, the students registered their justifications and thoughts on sheets of paper given to them at each session. Besides, photography was utilized to capture specific moments of gameplay, screenshots of the game, student victories, and interaction between pairs.

For the fieldwork sessions dedicated to using the digital game *Batalha com Dados*, we adopted the seven moments of the game recommended by Grando (2004) as a methodological approach to mediate the use of this game in the school context where the research was conducted.

After conducting the research, it was possible to establish that the analyses of the audio and video recordings would be conducted based on the seven phases of the analytical model proposed by Powell and Silva (2015). We watched the videos and listened to the audio recordings several times, making notes, highlighting, and transcribing moments that we selected as highlights for our research objective. Additionally, we relied on the field journals produced and on the written registers of the students to assist in choosing the critical events.

According to the objectives of the article and due to space limitations, not all data production instruments will be highlighted, and not all fieldwork moments will be described. The focus will be on analyzing the students’ initial contact with the digital game *Batalha com Dados*.

4 The first encounter with the digital game *Batalha com Dados*

The first meeting with the 5th grade students was held to get to know the participants of

² Available at: <https://batalhacomdados.com.br/>

the research and also for them to understand the nature of the study, who the teacher-researcher was, as well as the purpose of the sessions. In this manner, it was divided into four stages: introduction, discussion about what research and Probability entail, signing of the FICF by the students, and responses to an individual questionnaire. In the second meeting, an investigation into the students' knowledge was conducted in order to identify what they already knew about Probability based on the prescribed curriculum.

The third meeting with the students took place on 27th September, 2022, and we planned that, during this session, the students would engage with the first three phases of the game, according to Grando (2004). In this way, the students had the opportunity to familiarize themselves with the materials necessary to use the digital game, the first phase of the game (Grando, 2004), by getting to know the resource used and relating it to other experiences they have had. With the aim of facilitating this familiarization, the researcher conducted simulations with the students, demonstrating possible moves and thereby enabling an understanding of how the game worked.

Considering the moment of familiarization of the students with the digital game, the organization of the auditorium, and the students' access to the platform where the game was inserted, we produced an infographic (Figure 1) with the necessary step-by-step instructions for students to have an easier time playing. This step-by-step guide was displayed on the digital whiteboard in the auditorium during all sessions dedicated to the use of the digital game *Batalha com Dados*.

Figure 1: Infographic with step-by-step instructions to access the game



Source: Avelar (2023)

In this way, even though we had already read and explained the instructions, when students felt a bit lost, they would consult the image and often manage to organize themselves. Another initiative carried out with the intention of reducing challenges during access to the digital game was the insertion of the nickname and password (information necessary to enter the game platform) on the back of the badges that were provided to each student at the beginning of the sessions. We later understood how essential this strategy was, as it contributed to few students needing assistance to access the digital game *Batalha com Dados*, which increased the

time dedicated to gameplay.

During this session, students also had moments dedicated to understanding the rules of the game, the second phase of the game (Grando, 2004), which will be presented later. In order to facilitate the students' understanding, we dedicated some time during the session to explain the rules of the game to the entire class, with the support of the infographic. At various times, it was necessary for the researcher to explain the rules again to a specific pair, and one strategy we used was to conduct a test round with the pairs, as recommended by Grando (2004). In this way, we infer that "reading the rule also becomes a problem to be solved, prompting the reader to seek ways to start the moves, infer, discuss, and experience writing, raising hypotheses, conjectures, as well as appropriating mathematical language" (Luvison & Grando, 2018, p. 94). Thus, students saw in practice how the game worked, and at various times, after understanding the rules, they sought new paths and resolved to restart the game to make new bets.

With this, students faced the third moment of the game recommended by Grando (2004), the *game for the game's sake*, playing, then, to ensure the rules. Therefore, students made their first bets and moves to understand the rules and ensure they were followed. Since it is a digital game, the rules regarding the game mechanics are already fulfilled automatically by its own programming. However, it is still essential for students to ensure that, in each turn, the correct player performs the necessary actions. Thus, this session was dedicated to allowing students to play spontaneously, as well as recognize, understand, and follow the rules.

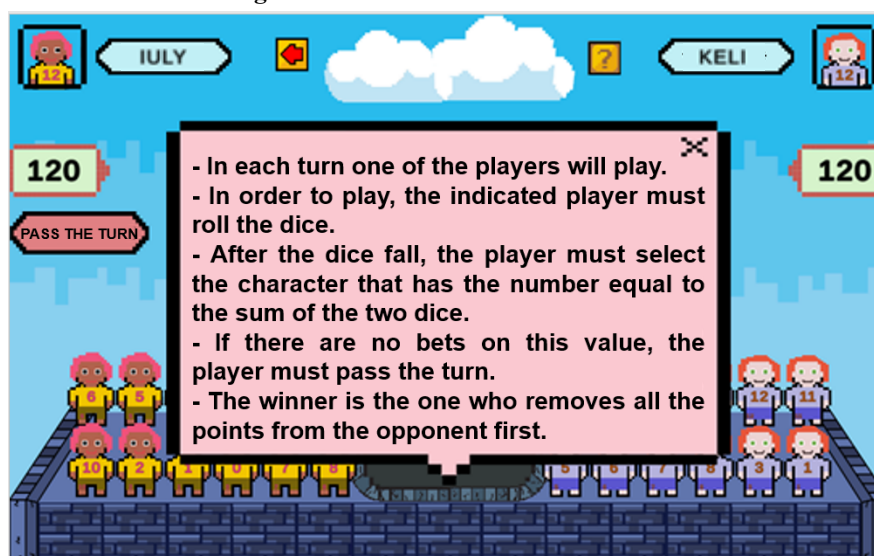
At the end of the session, the researcher asked the students: "*Was the first time you played the same as the second?*". In all classes, they answered no. Additionally, one of the students from 5th grade A wished to explain that: "*The first time, we did not really know how the game worked, so in the second and third times, we were already used to it and knew how to play properly*". In his statement, the student highlighted the importance of allowing students a moment to get to know the game and play to understand the rules, as recommended by Grando (2004).

Initially, we thought that verbal interventions, the fourth moment of the game (Grando, 2004), would not occur in this session dedicated to the first contact with the game. However, in practice, due to the heterogeneous nature of the classes, some students felt the need to inquire the researcher about how the game worked, and, at the same time, the researcher wished to intervene with questions to understand the students' decisions, as well as to assist them in understanding the game and the mathematical concepts related to it. Thus, verbal pedagogical interventions began from the first encounter with the game and were present throughout all the others.

Finally, in this first encounter with the game, we provided students with a sheet of paper for them to make a free and spontaneous register. These writings are recommended with the "objective of noting information about the game, scores made by the player or by the group itself, or even those that the game 'asks' for during the matches" (Luvison & Grando, 2018, p. 115). The intention was for students to note down whatever they felt necessary. It was not mandatory to write down any specific information.

In all classes, students were very curious when they entered the auditorium and saw the game's initial screen on the tablet. Most students took a moment to match the colors available on the game selection screen. When starting the game and moving to the betting screen, the researcher felt the need to explain the rules of the game to the students (Figure 2). After all, they did not know why they would bet those numbers and what the purpose of that action would be within the game. Hence, we read the game rules for all students.

Figure 2: Game rules read with students



Source: Avelar (2023)

At this point, having the step-by-step instructions displayed on the digital whiteboard was essential, but even so, most students did not understand the rules. The researcher also noticed that the majority of students did not show curiosity in clicking on the instructions button, both on the betting screen and on the game screen. Even after explaining the game rules to all students, some pairs remained with doubts and requested the researcher's help. This occurred with Esther's pair from 5th grade C, leading to the following dialogue:

Esther: *It says "roll the dice" here, what does that mean?*

Researcher: *Click on the button that says "Esther, roll the dice".*

Esther: *Ohhh.*

Researcher: *The dice rolled, and now? What's the sum of the values on those dice?*

Esther: *What do you mean?*

Researcher: *What numbers appeared on the dice?*

Esther: *4 and 3.*

Researcher: *The sum of those numbers is...?*

Esther: *7.*

Researcher: *That's right, and do you have a little character with the number 7 on its shirt?*

Esther: *I do.*

Researcher: *Then click on it.*

Esther: *Oh, it disappeared.*

Researcher: *And what happened to Mayla's points?*

Esther: *They decreased.*

Researcher: *That's right, they decreased by 10 points. Now it's Mayla's turn.*

The students nodded in agreement and smiled, indicating that they had understood how the game works, and they continued playing. Taking advantage of the moment regarding the game rules, we noticed the challenge for students to understand the rule indicating the winner and, in case of no winner, what would happen in a tie. Several students questioned why they

should be the winner since they had more points at the time the game tied or at the moment they wished to restart the game.

Gabriel: *The 1 still is not showing up.*

Researcher: *Why hasn't the 1 appeared yet?*

Gabriel: *Because there are 2 dice. It will never roll a 1.*

Researcher: *Do you want to start over?*

Gabriel: *Yes.*

Vinícius: *Oh, no.*

Researcher: *Why didn't you want to leave the game?*

Vinícius: *Because I would be left with only 1 first, then I would win.*

Researcher: *Do you think whoever gets 1 first wins?*

Vinícius: *No, but I would only have one character, so I would win.*

Researcher: *Look at the rule of the game. The one who takes all the opponent's points first wins. So, would someone win?*

Gabriel: *No.*

Researcher: *What would you do?*

Vinícius: *Tie.*

The researcher explained to many pairs several times that to win, it was necessary to remove all points from your opponent. Nevertheless, some students remained reluctant to accept the tie. At this point, realizing the students' difficulty in understanding the victory criterion and aiming to allow the group to understand the rules, the researcher requested everyone's attention. With the students already familiar with the game, everyone stopped for a moment to reread the rules together. At this moment, it was possible to inquire the students about the victory condition:

Researcher: *By reading the rules, do you think if one player ends up with two characters, one with the number 1 and the other with the number 13, and another player ends up with only one character with the number 1, that any of these players will win the game?*

Mayla: *Yes, the one with one character wins. He took more points from the enemy.*

Researcher: *But what's the last rule?*

Mayla: *The one who takes all the points from the opponent first wins.*

Emilly: *How can he win if he didn't take all the points from his opponent? In order to win, you have to take all of them, there can't be any characters left on the screen. If there are, you don't win. That's it!*

Alice: *Ahhh, so whoever ends up with fewer characters on the screen doesn't win?*

Luan: *That's right, I also thought before that the one with fewer characters wins. It was only after rereading the rules with the teacher that I understood it wasn't that. You have to take all the characters, not end up with fewer.*

With this, the students who had not yet understood the rule understood, through the explanations of their peers, that it was not possible to win just by getting closer to victory. These moments allow "establishing, collectively, an exchange of ideas with the whole group, reading, inferring, raising hypotheses, and recording impressions, so that this discussion makes sense to them" (Luvison & Grando, 2018, p. 109).

A pair caught our attention. When one of the students won, both were very happy. The researcher asked the one who had lost if she was not sad, and her response was: “*No, teacher, I am very happy. My partner won, and we discovered the game’s strategy*”. These students did not see their partner as an opponent; at that moment, for them, the adversary was the game itself, we agree that “when the individual is attracted to the problem, player and opponent move around a goal, elaborating joint actions towards resolution” (Luvison & Grando, 2018, p. 71).

Like these students, several others became anxious and eager to understand what the game’s tactic was. They asked the researcher multiple times what strategy to use to win the game. At the end of the session, the researcher asked each class if they enjoyed the game, and the students from all three classes shouted “*Yessss*”. When asked why they liked the game, several answers were given:

João: *Because it's really fun.*

Unidentified student (5th grade A): *It relieved my stress.*

João: *This game is made for thinking.*

Researcher: *Thinking about what?*

João: *Thinking about which number will come up more.*

Adryan: *Teacher, tell us the secret.*

Emilly: *Meeeeee, but I'm so mad, because she accidentally clicked to pass the turn and it was the number I was going to win. Then it didn't come out again, because it was a hard number to come out and there wasn't enough time to win.*

Layza: *I loved it, very cool.*

Sofia: *The competition.*

The students ended the session very excited. They told us that the competition is the best part of the game and that this game made them think. Everyone left excited for the next day and eager to discover the game’s strategy.

4.1 Analyzing the students’ bets

Upon analyzing the videos, recordings, and registers generated through the game, we noticed that the majority of pairs could not immediately, upon hearing the game rules, define a good strategy for choosing numbers. Curious to understand the criteria chosen by the students, the researcher began verbal interventions, questioning the pairs about the reasons behind their number choices when placing their bets.

Arthur: *Some, I really like these numbers.*

Maria Luiza: *It was random. But some here are because I like them.*

Juan: *Ah, I don't know.*

Gabriel: *Wow, I bet randomly. I just kept clicking.*

Brayan: *1, 2, 3, 4, 5, 6, 7, ... I put in sequence up to 12.*

Without the development of strategies, the students devoted themselves to understanding the rules of the game as they played. This fact demonstrates the importance of allowing students to perform the necessary actions recommended by Grando (2004) in the second phase of the game. Upon analyzing the registers generated by the game, we noticed that

the majority of pairs made impossible bets when playing for the first time. The aim of the research was precisely not to anticipate any strategy that might favor certain outcomes based on probability or chance.

There were pairs that required more time to identify the game's dynamics. In order to assist in investigating these students, the researcher suggested keeping registers.

Researcher: *And which numbers are coming up more often?*

Gabriel: *I don't know.*

Researcher: *How about you write it down on the sheet of paper?*

Juliana: *I don't know.*

Researcher: *Haven't you noticed yet?*

Lorrayne: *No.*

Researcher: *What if you start writing down the numbers that come up the most?*

This reminds us that students have different learning paces, and teachers need to be attentive and allow them to preserve their own time. In order to assist in the construction of these students' knowledge, the researcher attempted to suggest to the pairs to jot down the numbers that were coming up so that they could observe which numbers appeared more frequently. Nonetheless, the students remained resistant to using the register. When making this suggestion, the researcher attempted to guide the students so that through registering, they could adopt an investigative stance, thereby enabling them to identify patterns in the game that would allow them to better plan their strategies.

We noticed that the sheets of paper provided for free registering, in case students felt the need to jot down something, were not used by the majority; only one student from the three classes used them. When asked what she was writing down, the student replied that she would use the register (Figure 3) to write down the results of the sums that came up when rolling the dice. Upon seeing the register made by the student, we realize that she felt the need to already begin conceptualizing the sample space of the sum of rolling two dice. Consequently, the student started identifying which numbers would be possible outcomes when two dice were rolled, as well as the result of the sum.

Figure 3: Registers of student Camilly's third session

3º encontro

Nome: Camilly

Data: 27/09/22 Turma: 5A

Registros do Jogo

1		
2		
3		
4		
5	$1+1=2$	$1+2=3$
6	$2+2=4$	$2+3=5$
7	$3+3=6$	$3+4=7$
8	$4+4=8$	$4+5=9$
9	$5+5=10$	$5+6=11$
10	$6+6=12$	$6+7=13$

Source: Avelar (2023)

By making this writing move, Camilly related some possible outcomes through experimentation, initiating the observation of the mathematical concepts involved in the game. Hence, the student connected the registers made to the path of reflection, as elucidated by Luvison and Grando (2018). The student did not settle for the failure of the first game and decided to jot down the results of possible sums to reconsider bets in a future round. This action allowed the student to reflect and develop new strategies, analyzing those that had already been executed.

When we consider the construction of students' knowledge for understanding impossible events, we realize that most pairs, after some time playing the first round, identified that some of the numbers they bet on would be impossible to come up.

Marcella: *The number 1 can't come up.*

Researcher: *Why?*

Marcella: *Because there's no 0. There's no side with nothing on the die. Esther also chose 1.*

Researcher: *Do you think any of you will win?*

Esther: *No.*

Researcher: *How did you choose the numbers in the beginning?*

Marcella: *Randomly.*

Marcella: *Oh my God. How are we going to finish the game?*

Researcher: *And you, Esther, will you be able to finish?*

Esther: *I don't know, because I have 0 and 1.*

Researcher: *And 0? Can it?*

Esther: *Neither.*

Researcher: *Why not?*

Esther: *Because 0, no number can appear here, and another number will appear here, and then it results in another number, like if 1 plus 1 appears, it will give 2. Then, it's impossible.*

This pair, like several others, managed, through the gameplay, to analyze their bets and, through their moves, identify the presence of impossible events. As a result, the students, for the most part, were able to, through experimentation, form hypotheses and identify that the numbers 0 and 1 were impossible to obtain by summing the results of rolling two dice, and, therefore, they wanted to restart the games. These dialogues and perceptions demonstrate how students began the development of Probabilistic Literacy. Luvison and Grando (2018) emphasize that the nature of the game allows players to reflect, initially, on their own actions. By playing, students begin to find meaning and show a desire to play and solve a problem.

These students began the process of making better decisions when placing their bets, and started using mathematical language to justify their analyses, since “mathematical language is constructed from the moment students communicate their conclusions and hypotheses, allowing concepts to be expressed primarily through these narratives: hence the presence of the game as a (re)signifier of language itself” (Luvison & Grando, 2018, p. 77).

Some pairs quickly realized that the number 0 or the number 1 were impossible. Nonetheless, the number 13 required a more thorough analysis for the students to reach such a conclusion. The duo formed by Ana and Karen identified the impossibility of the number 0, but, in this session, the students failed to realize that the numbers 1 and 13 would also be impossible. Therefore, one of the members of the duo concluded that she could not win the

game because she chose the number 0 in her bets. However, she did not identify that her opponent could not win either, since she bet on the numbers 1 and 13.

Ana: *How are you going to get 0?*

Karen: *I don't know. Because there isn't. That's why I already know I'm going to lose.*

Researcher: *And do you think Ana will win? What numbers are missing for Ana?*

Ana: *2, 11, 1, 7, 13, and 1.*

Researcher: *Let's see what happens?*

Karen: *Wow, I got my last one.*

Researcher: *Now, which number is missing, Karen?*

Karen: *Only 0, the darn 0.*

These students played two rounds that day. Upon analyzing the registers generated by the game and the audio recordings, we observed that, in the first round, both made random bets, and in the second round, their bets were: 1-2-3-4-5-6-7-8-9-10-11-12. At that moment, for the students, distributing a bet on each number, starting from 1, was a better strategy than choosing numbers randomly. Through experimentation, the students concluded, by the end of the session, that *"It goes wrong to put it randomly"* and that *"Ehhh in order, to win you have to choose better"*.

We can observe that, in several conversations, the students were not yet fully familiar with the use of terms commonly associated with probabilistic events, such as *probable*, *possible*, *impossible*, *very likely*, *unlikely*, and so on. Notwithstanding, the students used other words, like *never* and *very difficult*, as ways to express their understanding, even without using the previously mentioned terms.

We agree with Gal (2005) that some of the terms addressed in the elements of knowledge of the Probabilistic Literacy model are not easily understood and can only be explored after the development of an accumulative process. Since this is the first encounter with the game, we agree with Gal (2005) that the language should be developed initially around "abstract constructs", in which the student develops "familiarity with terms and phrases related to relevant abstract constructs" (Gal, 2005, p. 55). Since this was the first encounter with the game, we consider that the understanding and development of the appropriation of the Probability-specific vocabulary began through the matches, dialogues, and interactions.

Some students, on this first day, although they did not reach a conclusion about all the impossible events, they managed to identify the most probable events.

Sofia: *I'm only going to repeat 6, 7, and 8.*

Researcher: *Are you only going to put 6, 7, and 8 next time?*

Sofia: *Yeah, because only those come up. 13 never comes out. 13 and 2 never come out.*

Although Sofia managed to identify that the numbers 6, 7, and 8 appeared more frequently in the results of the sums, she had not yet observed the impossibility associated with the number 13. Despite believing that the number 13 would never come up, the student compared it to the number 2, which despite having a small chance of being obtained during the rolls, was still possible. For Sofia, both numbers never come up. This movement of the game shows us that, in addition to each student having their own learning pace, the experiences of

the game, the choices, the reflections, and the experiments allow each one to reach different conclusions, which may be right or not.

Another student, during the gameplay, managed to observe the frequency and conclude both about the three impossible numbers and about which number came up most frequently during the rolls. This student was able to analyze, reflect, and conclude through her choices. Nonetheless, she still could not justify why the number 7 appeared more often:

Maria Luiza: *Actually, I got one of each, except for 0, 1, and 13, and I also didn't get 2 and 12, so I added more 7.*

Researcher: *Why did you add more 7?*

Maria Luiza: *Because it comes up a lot.*

Researcher: *Why do you think it comes up a lot?*

Maria Luiza: *I don't know.*

The difficulty in understanding why some numbers appear more than others permeated other students, who, through experimenting with the game, managed to conclude, even without registering, the numbers that came up most frequently.

Yuri: *Only 6 and 7 are coming up.*

Researcher: *How did you realize that only 6 and 7 are coming up?*

Yuri: *Because they keep coming up all the time.*

These dialogues highlight the importance of students having the opportunity to play the game as many times as they feel necessary. With each new round, students have the chance to reflect, form hypotheses, discuss with their opponents — who in these moments become partners in search of a solution to the problem, for the greater good — and ultimately, to win the game. During the transcriptions, we noticed a critical moment from an unidentified pair, obscured by excessive background noise in the recorded audio.

Researcher: *You started over. Why?*

Unidentified student: *Because only repeated numbers were coming up.*

Researcher: *And which number was repeating?*

Unidentified student: *7 and 6.*

Researcher: *Why do you think 7 and 6 were coming up so much?*

Unidentified student: *Because I didn't have them.*

Researcher: *Do you think it is just because you did not have them?*

Unidentified student: *It was bad luck.*

Researcher: *Do you think it was Mathematics or bad luck?*

Unidentified student: *Bad luck, because we did the calculations right.*

Once again, this pair, through the game's dynamics, managed to form hypotheses due to experimentation and the frequency with which numbers appeared. However, the pair could not identify the reasons behind the higher occurrence of the numbers 6 and 7, much like the majority of students. When students noticed that some numbers appeared more frequently, the

conclusion arose that this occurrence was linked to the luck of the player, or unluckiness if the student had not bet on those numbers. The students have beliefs and attitudes that prevent it from being possible to identify to what extent their impressions of the plays would be related to real facts or based on their beliefs, conservative thoughts, or excessive confidence. This fact fits within the disposition elements indicated by Gal (2005) regarding the development of a process of Probabilistic Literacy. Furthermore, this specific pair could not conclude that numbers 6 and 7 appeared more frequently due to some mathematical concept because they believed that, having performed all the necessary operations correctly, it would not be possible for the justification to be related to mathematical knowledge. This fact is linked to an excessive confidence regarding the content and their knowledge.

Some students, after making several moves, begin to notice that certain numbers appeared more frequently than others. Consequently, they decide to restart the game and choose these numbers since, for the students, the purpose of the session was to win the game.

Talita: We only put 7, 6, and 9. But now it's 11, look at that! Before, it was only 7, and now that we chose others, it is only 2, 11...

Researcher: What do you think is happening?

Talita: I don't know, Mathematics is crazy.

Researcher: Mathematics is crazy?

Researcher: Which of you diversified the numbers more?

Talita: Ana did, she put less 7.

Researcher: You trusted 7 a lot, right, Talita?

Talita: Yeah.

The students decided to restart the game once again, and this time, they diversified their numbers while keeping number 7 with higher frequency. With this new strategy, the pair managed to win the game. At the end of the session, one of the students enthusiastically shared with the researcher that, after analyzing, reflecting, and discussing with her partner, they had concluded the best strategy.

Talita: Our plan worked.

Researcher: What was your plan?

Talita: Putting a bunch of 7s, 6s, 9s, and 8s too.

Researcher: Why do you think it worked?

Talita: I couldn't figure that out.

Researcher: Was it luck, perhaps?

Ana: No, because it didn't work the first time.

During the process, these students were able to perceive the variation, randomness, unpredictability, and uncertainty related to the sum of the result when rolling two dice. These elements of knowledge are recommended by Gal (2005) for the development of Probabilistic Literacy with students. Through experimenting with the game, the students concluded the session by understanding the “general abstract nature of these ideas only intuitively” (Gal, 2005, p. 52).

Already irritated at not being able to unravel the game's strategy, a student decided to

interrupt a researcher's dialogue by asking:

Gabriel: *Do you control it?*

Researcher: *Are you thinking I control the game?*

Gabriel: *Isn't the game yours?*

Researcher: *The game was developed by me.*

Gabriel: *Sooooo.*

Researcher: *But I don't control it, it's Mathematics.*

Gabriel: *Mathematics? It can't be Mathematics. Mathematics is right. You made it this way.*

This student, unable to understand the mathematical strategies related to gameplay, believed that the game functioned in this way because, supposedly, we had programmed it to be this way. At various moments, the students struggled to establish mathematical relationships without performing an operation. Since the only operation required to play *Batalha com Dados* is addition, students tend not to believe that there is *another* Mathematics behind the strategies to win the game.

At the end of the day, while talking with two students, we were able to highlight the importance of teamwork.

Researcher: *What did you think of the game?*

Arthur: *It's really good.*

Researcher: *Was it easy to think about 0, 1, and 13?*

Arthur: *It's because there is no 7 on the die.*

Researcher: *But how did you realize that?*

Arthur: *By playing, right?*

Researcher: *Many or few times?*

Arthur: *Many. It was only now at the end that I realized it.*

Researcher: *Did you have to play a lot to realize that 0, 1, and 13 didn't work?*

João: *Yes, and it wasn't even me who realized, it was Arthur.*

The majority of students left this session with the same perception as João and Arthur. Their remarks emphasized the importance of teamwork, dialogue with others, and the mediating role played by the researcher during the game, intervening orally through questioning. At a certain point in the session, the majority of students were striving to achieve the ultimate goal: someone winning the game. Through the game, students feel challenged, initially with the rules, then with the choices, which are followed by analyses and dialogues that enable students to draw conclusions leading them to victory, or bringing them closer to it.

5 Conclusion

Throughout the conducted research, we were able to understand how the use of digital games can be a strategy in the teaching and learning of Mathematics, particularly in the field of Probability. Through the various game situations, students are challenged to make decisions based on probabilities, analyzing and comparing the outcomes of different dice rolls. In this way, they can develop skills in logical reasoning, estimation, and decision-making, as well as

understand the random nature of events.

Additionally, the digital game *Batalha com Dados* provides the opportunity for students to work collaboratively from the first contact, stimulating the development of social skills such as communication and cooperation. By interacting with their peers during the games, they can discuss strategies, share knowledge, and collectively build a deeper understanding of probability concepts.

Upon analyzing the students' first encounter with the game, we also concluded that merely acquainting themselves with the rules of the game did not enable them to develop effective strategies for selecting the numbers they would bet on. With this session, it was possible to conclude that the researcher's mediation, which aimed to start developing with the students the construction of the sample space when rolling two dice, will be crucial to contextualize the game activities, propose reflections, ask questions, and provide support to the students. Nevertheless, even in the initial process of constructing Probabilistic Literacy, the students already realized that it is necessary to think carefully before placing their bets.

It is important to emphasize that the use of digital games does not replace the role of the teacher. On the contrary, the teacher plays a crucial mediating role. Therefore, the game should be used as a supplementary resource to teaching, integrating with other pedagogical practices and educational resources. We noticed, over the course of the subsequent sessions, that students began to allow themselves to try making registering, and through this action, they accelerated the development of their probabilistic knowledge.

In light of the results obtained in this research, it is recommended that teachers and Mathematics educators consider including the digital game *Batalha com Dados* in their educational practices. By doing so, they will provide students with an opportunity to learn about Probability in a practical, interactive, and enjoyable manner. The use of this game, combined with the appropriate mediation of the teacher, can contribute to the successful initiation of Probabilistic Literacy construction at this fundamental stage of student development, helping them become critical and skilled citizens in decision-making in various everyday situations. Also, based on the results obtained, it is hoped that future research will involve teachers who have implemented the game in their classes.

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