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THE DIGITAL GAME "PROBABILITY IN ACTION": MOTIVATION, USER EXPERIENCE AND LEARNING

O JOGO DIGITAL "PROBABILIDADE EM AÇÃO": MOTIVAÇÃO, EXPERIÊNCIA DO USUÁRIO E APRENDIZAGEM

EL JUEGO DIGITAL "PROBABILIDAD EN ACCIÓN": MOTIVACIÓN, EXPERIENCIA DE USUARIO Y APRENDIZAJE

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ABSTRACT

It started with the contribution of software engineering in the construction and inclusion of digital educational games for teaching and learning about probability. The evaluation of the digital game "Probability in Action" performed by 29 students (10 and 11 years old) from two classes at a public school in the city of Barueri, São Paulo, Brazil, is presented, according to the quality model of educational games, considering three subcomponents (motivation, user experience and learning) and 11 dimensions (attention; relevance; trust; satisfaction; immersion; social interaction; challenge; fun; competence; short- and long-term learning). The results obtained through the analysis of the students' responses are characterized as positive, in addition to being configured as an option to support the teaching and learning process of probability for Elementary School.

Keywords: Educational digital game. Software engineering. Probability teaching. Elementary education.

RESUMO

Partiu-se da contribuição da engenharia de software na construção e inclusão de jogos educacionais digitais para as práticas de ensino e aprendizagem de probabilidade. Apresenta-se a avaliação do jogo digital "Probabilidade em Ação" realizado por 29 alunos (10 e 11 anos) de duas turmas de uma escola pública do município de Barueri, São Paulo, Brasil, segundo o modelo de qualidade de jogos educacionais, considerando três subcomponentes (motivação, experiência do usuário e aprendizagem) e 11 dimensões (atenção; relevância; confiança; satisfação; imersão; interação social; desafio; diversão; competência; aprendizado de curto e longo prazo). Os resultados obtidos por meio da análise das respostas dos alunos caracterizam-se como positivas, além de se configurar como opção para apoiar o processo de ensino e aprendizagem da probabilidade para o Ensino Fundamental.

Palavras-chave: Jogo digital educacional. Engenharia de software. Ensino de probabilidade. Ensino Fundamental.

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RESUMEN

Se inició con el aporte de la ingeniería de software en la construcción e inclusión de juegos educativos digitales para la enseñanza y aprendizaje de la probabilidad. Se presenta la evaluación del juego digital "Probabilidad en Acción" realizado por 29 alumnos (10 y 11 años) de dos clases de una escuela pública de la ciudad de Barueri, São Paulo, Brasil, según el modelo de calidad de juegos educativos, considerando tres subcomponentes (motivación, experiencia de usuario y aprendizaje) y 11 dimensiones (atención; relevancia; confianza; satisfacción; inmersión; interacción social; desafío; divertido; competencia; aprendizaje a corto y largo plazo.). Los resultados obtenidos mediante el análisis de las respuestas de los estudiantes se caracterizan como positivos, además de configurarse como una opción de apoyo al proceso de enseñanza y aprendizaje de la probabilidad para la Enseñanza Primaria.

Palabras clave: Juego digital educativo. Ingeniería del software. Enseñanza de la probabilidad. Educación primaria.

1 INTRODUCTION

Considering that there is a real need for citizens to master basic probability knowledge, we believe that this has a relevant role in their training. According to Bennett (2003), learning probability contributes to the development of critical thinking, which allows citizens to understand and communicate different types of information present in countless situations of everyday life in which random phenomena, chance and uncertainty are present. Furthermore, it is believed that the teaching of probability is little evidenced in the initial years of Elementary School, requiring research in this area.

Thinking about these points of view and believing that the game is capable of enabling simulations of tasks that provoke and require immediate solutions, thus characterizing itself as an effective resource for the exercise of active learning, we chose to create a digital game whose movement of the pieces will be done through the correct answers of the players to the question cards that will be composed of problem situations that are part of the child's daily life.

Furthermore, digital games, in addition to entertainment, have been used for various purposes, one of which is educational games, whose purpose is to mediate learning, the construction of some type of knowledge or the maturation of motor or cognitive skills.

Referring to probability, the game created and evaluated according to its quality can be considered as a concrete reference, as it provides the simulation of a variety of cases that can favor the formulation and organization of ideas generated from the dynamics of the game itself, that is, the communication and arguments of the players themselves when faced with problem situations.

A good comprehension of probability can help the individual to understand the risks and possible benefits of an action and to ensure fairness in everyday life (BRYANT; NUNES, 2012). Considering the importance of probability, many countries place it as part of the school mathematics curriculum, and there was a movement that introduced probability earlier at the elementary school level (FRYKHOLM, 2001).

In Brazil, the National Common Curricular Base - BNCC (BRASIL, 2018), indicates that uncertainty and data processing should be studied in the thematic unit Probability and Statistics, proposing the approach of concepts, facts and procedures present in many problem situations of science and technology observed in everyday life. Regarding the study of notions of probability, the purpose in the early years of elementary school (6 to 10 years) is to promote the understanding that not all phenomena are deterministic. For this, the beginning of the work proposal with probability is centered on the development of the notion of randomness, so that students understand that there are, for example, certain events, impossible events and probable events. Thus, didactic resources such as games, books, videos, calculators, spreadsheets, among others, play an essential role in understanding and using probabilistic notions, and these materials need to be integrated into situations that lead to reflection and systematization, to initiate a formalization process (BRASIL, 2018).

Thus, this article aims to evaluate the educational digital game “Probability in Action” according to software engineering, through the considerations of 29 students from the fifth year of an elementary school class located in Barueri, São Paulo, Brazil.

In addition to this introduction, where we present the justification, problem and objective of the research, the sequence of this text is divided into four other sections: the theoretical framework, containing a brief contextualization about the potential of using games for the teaching and learning process of general form and for teaching probability; the methodology, where we detail the procedures adopted to carry out the research; the analysis and results, where we present the evaluation of the students of the digital game “Probability in Action” and, finally, the final considerations, where we conclude the study undertaken, highlighting our main reflections and presenting the future perspectives that arise from this search.

2 THEORETICAL FRAMEWORK

It is also important to highlight that digital games can be used to teach and learn in a playful way and, at the same time, imply being a tool capable of helping students overcome challenges in relation to their own learning. According to the United Nations Educational, Scientific and Cultural Organization – UNESCO website[1], it is not simply about making teaching resources accessible to all students but involves proactive thinking in identifying the obstacles that students encounter when trying access quality educational opportunities, such as educational games in digital format.

Alves (2007) highlights the importance of playful activity, including the use of games and storytelling, as it is the child's main manifestation, acquiring a vital role in the development of sensory, motor, socio-emotional and cognitive aspects, in addition to representing inclusion of children in the culture in which they are inserted. Digital games and other technological tools require skills such as logical reasoning, instigate curiosity and can serve to contextualize knowledge, enhancing interest in learning, stimulating skills necessary for formal learning at any level of education. For Hays (2005), generally, the decision to use educational games is based on assumptions of their effectiveness, rather than being based on more formal and concrete evaluations. He remembers that questionnaires have been used to evaluate games immediately after being applied to students, however, the measuring instruments are not standardized, that is, they have not undergone validation and reliability analysis, generating doubtful results.

According to Santos et al. (2008), one of the major challenges currently faced in the teaching of Software Engineering - SE is the need to use teaching methods that make the teaching-learning process more effective. However, it is important to have evidence of the benefits of games before using them in the classroom, because, for Navarro and Van der Hoek (2007), a more precise understanding of the results of using this type must be obtained through resources that allow us to know whether it is worth the costs and efforts involved in its adoption.

To Pressman and Maxim (2016), SE encompasses processes, methods and tools that enable professionals to develop high-quality software, imposing discipline on work that can

[1] https://pt.unesco.org/fieldoffice/brasilia/inclusive-education#:~:text=A%20educa%C3%A7%C3%A3o%20inclusiva%20n%C3%A3o%20%C3%A9,obst%C3%A1culos%20que%20levam%20%C3%A0%20exclus%C3%A3o.

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become chaotic, allowing its development adapted to its approach, in the manner more convenient to your needs.

We further reinforce, taking Savi et al. (2011), that for games to have an intended educational effect, it is necessary to be developed within the context of the instructional unit in which they will be used, to have clearly defined learning objectives in alignment with the learning objectives of the instructional unit and to be systematically evaluated.

Furthermore, Alsina (2011) considers that the game helps the child to escape reality to resolve conflicts in a symbolic way and, thus, allows the creation of a series of mental processes that help to internalize mathematical knowledge, but in a pleasant, playful way and in which socializing is also encouraged. Play motivates, excites, and helps to overcome the fear of failure in the face of problems or operations.

Furthermore, we consider that the use of so-called digital games in teaching, the main focus of this work, is a promising field that needs to be more disseminated in education, because, according to Araújo et al. (2012), learning objects, as teaching tools, can bring to the classroom many learning possibilities that go through new content approaches and the motivation to learn depending on the media in which they are produced.

In addition, we start from the previously consideration that the popularity of digital games in educational contexts has increased, contributing positively to this scenario, the constant advances in software and hardware. These aspects have facilitated the development of high-quality games, as rapid advances in technology and improvements in data transmission capacity make it possible to expand the public that consumes these games, opening countless possibilities to be explored as a tool in the educational context.

To define and justify the rise of digital games nowadays, Siena (2018) points out that, considering technological innovations, the universe of games, aiming to meet user requirements, was driven to keep up with these new advances and, therefore, common games were adapting, thus emerging electronic games or digital games, impacting the culture of today's society, creating habits. It is important to remember that their history is based on table games, technological advances and the development of visual media.

Still in the context of digital games, Lealdino (2013) indicates that these are a new format and quite flexible, as it allows adding animations, texts and sounds. In addition to being able to use all these means, the computer is an object that is strongly present in everyday life, therefore, it is believed that the game becomes a didactic material with great potential and the computer is the necessary platform for the construction and applicability of this type of material.

Focusing on games and indicating the importance of probability since the initial formation of Basic Education, Vásquez and Alsina (2014) recall that the teaching of probability should start with very simple activities in which chance is present, thus favoring the emergence of intuitions, adding the importance of children apprehending the concept of chance, suggesting the performance of random games, such as throwing, for example, coins and dice.

Ricci and Santos (2016) argue that digital games occupy a privileged place in students' preferences and can be used in various ways and in different contexts. According to Krüger and Cruz (2001), what feeds the fascination with digital games is the possibility of direct interaction with the game, combined with the degree of realism it has. The use of digital games, according to Moita (2006), brings playfulness to the field of learning, becoming pleasurable for students, through interactive participation.

For Gee (2009), the great potential of games as a teaching tool is largely due to the possibility of being highly engaging problem-solving spaces. In addition, for Gee and Morgridge (2007), these allow players or students to think like scientists, as they have a cycle typical of experimental science, making it possible to: 1) postulate hypotheses; 2) explore the world; 3) get a reaction; 4) reflect on the results; 5) re-explore for better results.

Despite considering that games have the potential to function as valuable pedagogical tools, for Linehan et al. (2011) and Brom et al. (2011), there is still a need for these to produce reliable, valid and long-lasting educational results, or to be more efficient than traditional teaching structures.

Finally, Cassettari (2015) and Petri et al. (2018) indicate the benefits of using educational games to simulate activities and/or review concepts in a more motivating and attractive way for students and, considering Mitamura, Suzuki and Oohori (2012), that digital educational games are electronic games that use, for interaction with the user, an interface through an electronic device.

Below we present some aspects that indicate the potential of pedagogical games as a teaching tool to support the teaching of probability to students in the early years of elementary school.

3 THE POTENTIALITY OF PEDAGOGICAL GAMES TO AID PROBABILITY TEACHING

Góngora (2011) proposes that, to work on probabilistic concepts, games are used from a playful and pedagogical approach, so that not only do students have a first contact with this field of knowledge in a fun way, but also that the prior and everyday knowledge they have interacts with the new knowledge.

Alsina (2011) reminds us of that encouraging discovery through manipulative experience, rich in material resources, encourages meaningful learning, increases learner motivation, improves understanding and is more attractive than a theoretical class.

In the case of this work, referring to probability, the game created can be considered as a concrete reference, as it provides the simulation of a variety of cases that can favor the formulation and organization of ideas generated from the dynamics of the game itself, that is, the communication and arguments of the players themselves when faced with problem situations.

Vásquez and Alsina (2014) propose the use of concrete materials such as chips, dice and games of chance for the study of probability, as they will be of great help in conducting random experiments that will reinforce the concepts of probability.

Torra (2016) says that when exploring objects or situations, children are forced to investigate, they have to think, reason, think of the solution, look for different perspectives, compare with their partner, with other groups, with what they did before and express themselves. Even if they don't want to, there are doubts, questions, needs to satisfy their curiosity, to help the partner that will make them ask to learn and feel happy when they reach the solution.

Alsina (2011) explains how the game helps the child escape from reality to resolve conflicts in a symbolic way and, thus, create a series of mental processes that help to internalize mathematical knowledge, but in a pleasant, playful way and in which the Socialization is also encouraged. Playing motivates, excites and helps to overcome the fear of failure when faced with problems or operations.

Vásquez and Alsina (2014) remember that in the Chilean national curriculum, the teaching of probability began with very simple activities in which chance was present, thus favoring the emergence of intuitions. Considering the importance of children understanding the concept of chance, it was suggested that random games be played, for example, with coins and dice

Furthermore, as Londoño (2010) highlights, to learn intelligently and become aware of operations, there is nothing better than interacting with others and manipulating objects. An example could be designing a game to play with colleagues in which they have to roll a die a high number of times and thus check the probability of obtaining a specific number.

Below is the presentation of the methodological procedures of this study, following the theoretical model for evaluating the educational digital game, which is composed of three subcomponents: motivation; user experience and learning; that is, the quality of the educational game will be determined by the student's reaction to the motivating effect of the game, the experience of playing and the perceived learning gain.

4 METHODOLOGY

This research fits into the quantitative approach and is considered exploratory, descriptive and statistical (Hernández et al., 2014). In this context, we present below the sample analyzed, the instrument together with the variables considered and a brief summary of the analysis procedures carried out to answer the intended research questions.

The research, approved by the Ethics Committee under number 61382122.2.0000.5594, was applied to students from two 5th grade classes at a school in the city of Barueri, metropolitan region of São Paulo, Brazil. In these terms, the research participants add up to a total of 29 students aged between 10 and 11 years old, 55.2% female and another 44.8% male.

It is noteworthy that the access of students participating in this research to the educational digital game "Probability in Action" occurred at the time of its application in the classroom, remembering that they had no prior instructions on probabilistic concepts. It allowed them to get to know the mechanics, the rules, their logic and effectively play, answer probabilistic problems and learn more about everyday probability.

From the objective of evaluation, derive the measures referring to the data to be collected during the study in order to reach the objective of the evaluation. In this way, the theoretical model for evaluating the educational game is composed of three subcomponents (motivation - ARCS, user experience - UX and learning) and 11 dimensions. It is considered that in this model there is a causal relationship between the constructs and that the quality of the educational game will be determined by the student's reaction in relation to the motivating effect of the game, the experience when playing and the perceived learning gain.

The motivation subcomponent is decomposed based on the ARCS model (Keller, 2009), which presents four categories or dimensions to represent motivation in instructional projects: 1) Attention - obtaining and maintaining attention; 2) Relevance - the importance of the content;

3) Confidence - providing students with feelings of progress; 4) Satisfaction - importance and application of what was learned.

The user experience (UX) subcomponent contemplates the individual's interaction with the product, considering the thoughts, feelings, pleasure and other perceptions that result from the interaction (TULLIS; ALBERT, 2008). UX in games is often measured by a set of dimensions, but there is no consensus on what they are.

Analyzing four EU models in games (CALVILLO-GÁMEZ, 2009; TAKATALO et al. 2010) with the aim of identifying common dimensions, a proposal was reached with the dimensions that are most repeated among the models: 1) Immersion - deep involvement, that is, decreased awareness of what is around, alteration of the notion of time and the feeling of being emotionally involved with the game; 2) Challenge - be challenging enough and compatible with the player's skill level; 3) Competence - support the development of player skills; 4) Fun - playing is pleasant and fun, deserving to be recommended to friends; 5) Social interaction - feeling connected with others, empathy, cooperation and competition.

The learning subcomponent is measured based on two dimensions with the variables short-term learning (achieving the educational objectives of a course or activity) and long-term learning (verifying whether the game contributes to the student's education), based on the evaluation model of Moody and Sindre (2003).

In addition, Chart 2 shows the subcomponents of the scale and their respective dimensions, according to Savi et al. (2011), seeking the evaluation of the digital educational game "Probability in Action" by students of the fifth year of Elementary School.

Chart 2 - Subcomponents and their respective dimensions referring to the structure of the evaluation model of educational games.

Subcomponents of the scale of attitudes	Dimensions	Items
Motivation – ARCS	Attention	1 – 2 – 3
	Relevance	4 – 5 – 6
	Trust	7 – 8
	Satisfaction	9 – 10
User Experience - UX	Immersion	11 – 12 – 13
	Social interaction	14 – 15 – 16
	Challenge	17 – 18
	Fun	19 – 20 – 21 – 23
	Competence	22 – 24
Learning	Short term apprenticeship	25 – 26
	Long term learning	27

Source: Author's own elaboration

Prior to applying the scale, a code was established for proper tabulation of information, considering that all are expressed in a positive sense, and it is necessary that all are focused on the same direction so that there is homogeneity in the comparison scale. To generate the frequencies of the students' answers, the value of the mean and the standard deviation, each student established a number of points per item answered, expressed by a Likert scale, that is: I totally agree (5 points); partially agree (4 points); indifferent (3 points); partially disagree (2 points); strongly disagree (1 point).

It is noteworthy that, the higher the score obtained in each item or in the sum of the items, corresponds to a more positive evaluation in relation to their motivation to play, positive experience of the student when playing and perceiving learning in relation to probabilistic concepts through the game.

The internal consistency index was also determined for the entire scale and each of the subcomponents, using Cronbach's alpha (α), which is the most used method when measurements are performed in just one moment (Sijtsma, 2009). For Pasquali (2003), the analysis of internal consistency (Cronbach's alpha) refers to the calculation of the correlation that exists between each item of the scale (sum of the scores of all students for a given item) and the other items or the total of the same scale (total score of all scale items for each student).

In general, guidelines for the interpretation of alpha values are adopted, and George and Mallery (2019) suggest that alpha > 0.90 = excellent; alpha > 0.80 = good; alpha > 0.70 = acceptable; alpha > 0.60 = questionable; alpha > 0.50 = poor; alpha < 0.50 = unacceptable. Also, according to Nunnally (1978), Hair et al. (2009) and Santos et al. (2010), at least 0.70 would be an acceptable reliability value.

In the evaluation process of the digital pedagogical game, the correlation coefficient (Pearson) was also used for the sum of the scores of each of the items of the digital game evaluation scale associated with the total score of the scale. In addition, it was determined whether the correlations are statistically significant by comparing the p-value with a significance level of 0.05 or 0.01. A significance level of 0.05 indicates that the risk of concluding that there is a difference between a given scale item score and the total score is 5%.

According to Magalhães and Lima (2005), the correlation coefficient is the quotient between the covariance and the product of the standard deviations of x and y. The division by the product of the standard deviations has the function of standardizing the measure and making it possible to be used for comparisons with other variables. It is not difficult to verify that $\rho_{x,y}$

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is a dimensionless number and limited by 1, that is, $|\rho_{x,y}| \leq 1$. Its expression follows the same steps as for covariance, with values of $\rho_{x,y}$ close to ±1 indicate a strong correlation.

To reinforce the analysis procedures, the set of items was subjected to a normality analysis to verify the hypothesis that the data for each item could come from a variable with normal distribution. Descriptive analysis (histogram) and the non-parametric Kolmogorov-Smirnov test (K-S test) were used to verify whether the null hypothesis of the test (the sample being drawn from a population with normal distribution) was refuted ($p<0.001$).

In preparing the technical report, the free program PSPP version 1.6.2 was used to carry out the descriptive/statistical analyses. An Excel spreadsheet was used to generate the database.

The following topic presents the game "Probability in Action", its rules, the technological resources used to create the digital game, the design of the board model and the Questions (?) and Learn More (!) cards, among others, in addition to the skills considered according to the BNCC for students aged 6 to 10.

5 THE EDUCATIONAL DIGITAL GAME "PROBABILITY IN ACTION"

The educational digital game "Probability in Action" (Figure 1) aims to achieve learning objectives related to the notion of basic concepts of probability in the early years of Elementary School (6 to 10 years old) in Brazil and used the computer and the Construct 3 software as a medium.

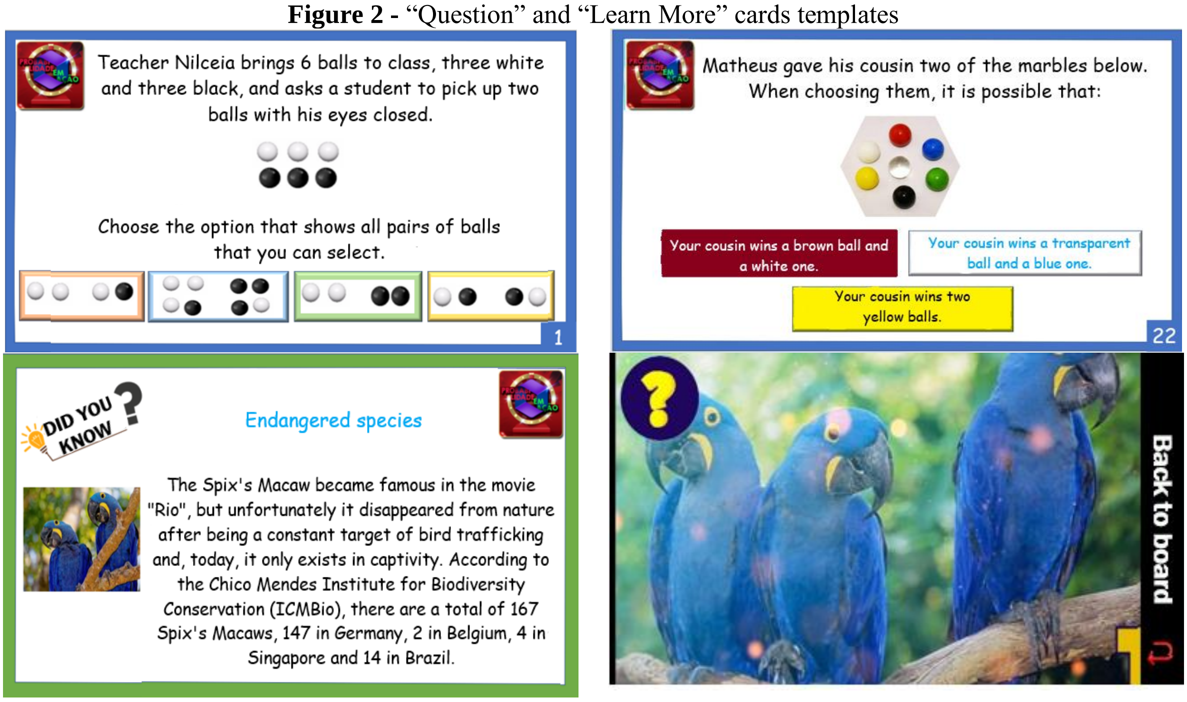
Figure 1 - Image of the digital game "Probability in Action" built in Construct 3.

Source: Author's own elaboration

The Construct 3, according to Donaghy (2023), is a game creation tool focused at both non-programmers and experienced programmers, allowing the quick creation of games, through the Drag-and-Drop style. The tool uses a visual editor and a behavior-based logic system, so education professionals can also build their games, applying the content of their classes through games. It's a browser-based game engine that lets you create games without having to use a single line of traditional code. Your core toolkit starts with Construct's unique event system. Combine that with built-in behaviors and you can have a working game in minutes. It's a great place to start and can help you create different games.

Regarding the game cards, we have two types (examples shown in Figure 2): (1) Questions (?), referring to the proposed tasks or questions (problem situations) that must be answered to walk on the board; and (2) Learn More (!), which bring curiosities and/or probabilistic information through verbal language and through different types of numerical representations (fractional, decimal and percentage). In all, 89 "Questions" cards and 18 "Learn More" cards were prepared, these in video format with animation.

Figure 2 - "Question" and "Learn More" cards templates



Source: Author's own elaboration

When preparing the tasks indicated in the "Question" cards, we highlight that the probabilistic notions were supported by the BNCC (BRASIL, 2018), bringing all the objects of knowledge and skills to be developed in the initial years, in the Teaching Program on probability and risk by Bryant and Nunes (2012), which aims to apprehend probabilistic

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concepts and in the North American document Guidelines for Assessment and Instruction in Statistics Education - GAISE II (BARGAGLIOTTI et al., 2020) for incorporating skills necessary to understand the advances related to teaching statistics and probability in recent years, maintaining the spirit of the first version called GAISE I (FRANKLIN et al., 2007).

The probabilistic contents to be addressed, according to the BNCC (BRASIL, 2018), for the early years of Elementary School (1st year to 5th year), are presented in Chart 1 (Description of knowledge objectives and description of skills).

Chart 1 - Objects of knowledge and skills of the probabilistic contents proposed in the BNCC from the 1st to the 6th year of Elementary School

Year attended	Knowledge objects	Skills
1st year	Notion of chance.	(EF01MA20) Classify events involving chance, such as "it will happen for sure", "maybe it will happen" and "it is impossible to happen", in everyday situations.
2nd year	Analysis of the idea of randomness in everyday situations.	(EF02MA21) Classify outcomes of random everyday events as "unlikely", "very likely", "unlikely" and "impossible".
3rd year	Analysis of the idea of chance in everyday situations: sample space.	(EF03MA25) Identify, in random family events, all possible outcomes, estimating those with greater or lesser chances of occurrence.
4th year	Chance analysis of random events.	(EF04MA26) Identify, among everyday random events, those that have a greater chance of occurring, recognizing characteristics of more likely results, without using fractions.
5th year Year attended	Sample space: chance analysis of random events. Probability calculation of equiprobable events.	(EF05MA22) Present all possible outcomes of a random experiment, estimating whether these outcomes are equally likely or not. (EF05MA23) Determining the probability of occurrence of an outcome in random events, when all possible outcomes have the same chance of occurring (equiprobable).

Source: Brasil (2018, p. 280-281; 284-285; 288-289; 292-293; 296-297)

Finally, to understand the dynamics of the game and make the assessment carried out by students clear and understandable, the rules of the digital game are presented, namely:

1) As soon as the user (student) starts the game, a dice that will be in continuous movement, rotating randomly, is visualized. This will happen again whenever the character representing the player (the student) ends his advance through the spaces.
2) To start the game, the player must click on the dice button for it to stop spinning and, consequently, stop at a number so that the character can advance on the board the number of spaces left on the dice.

3) Regarding the advancement of the characters in the squares of the path (board) to be covered during the game, if this is:

3.1) On the Backspace (X): The character moves back one space on the board.

3.2) In the Question box (?): A question, a problem situation will appear. If the student gets it right, he earns 3 points; if you make a mistake, you lose 1 point. By getting the answer right, in addition to scoring, a "bonus" is also earned, which will be directed to one of the four mini games (Figure 3) with elements of randomness, whose score won will be added to the overall score.

3.3) In the Learn More box (!): A layout opens with a video bringing information and probabilistic curiosities. After watching the video, just click on “return to the game”. When falling in this house, the player also earns a star and every 3 accumulated stars, he earns 2 points to be added to the overall score.

Figure 3 - Figures of the minigame environments of the digital game “Probability in Action”

Source: Author's own elaboration

The game ends, that is, the victory condition is given when the player reaches the end of the board with at least 15 points. If the player reaches the end of the board with a score below 15 points, his score will be maintained and the character will return to the beginning of the board so that he can restart the whole course and be able to fulfill his mission, that is, reach the end of the board with no Minimum 15 points earned.

After the presentation of the game and its structure, analysis and discussion of the results follows, starting from the methodological procedures presented that converge to the evaluation

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of the digital game “Probability in Action” considering aspects of motivation, user experience and learning of probabilistic concepts.

6 ANALYSIS AND RESULTS

Starting from a descriptive analysis, Table 1 presents the evaluation of the students of the digital game “Probability in Action” referring to the subcomponent “Motivation” and its different aspects (attention, relevance, confidence and satisfaction). It presents the absolute frequencies and percentages of the students' responses to each of the components of the game's evaluation scale, as well as the calculation of the average and the standard deviation, which allow to indicate (more or less) positive evaluation of these items.

Table 1 - Distribution of scale items for evaluating the motivation subcomponent

n	Subdimension	Propositions (Items)	Statistics (*)	Strongly Disagree	Partially Disagree	Neither agree or disagree	Partially Agree	Strongly Agree
1	Attention	The game design is attractive (interface or objects such as cards or boards).	4.14 (0.834)	0 (0.0%)	0 (0.0%)	8 (27.6%)	9 (31.0%)	12 (41.4%)
2	Attention	There was something interesting at the start of the game that captured my attention.	3.83 (1.037)	1 (3.4%)	2 (6.9%)	6 (20.7%)	12 (41.4%)	8 (27.6%)
3	Attention	The variation (in form, content or activities) helped keep me on my toes.	4.10 (0.976)	0 (0.0%)	2 (6.9%)	6 (20.7%)	8 (27.6%)	13 (44.8%)
4	Relevance	Game content is relevant to my interests.	3.83 (1.197)	1 (3.4%)	3 (10.3%)	8 (27.6%)	5 (17.2%)	12 (41.4%)
5	Relevance	The way this game works is suited to my way of learning.	3.79 (1.082)	1 (3.4%)	3 (10.3%)	5 (17.2%)	12 (41.5%)	8 (27.6%)
6	Relevance	The game content relates to another knowledge that I already had.	4.28 (0.841)	0 (0.0%)	0 (0.0%)	7 (24.1%)	7 (24.1%)	15 (51.7%)
7	Trust	It was easy to understand the game and start using it as study material.	4.55 (0.686)	0 (0.0%)	0 (0.0%)	3 (10.5%)	7 (24.1%)	19 (65.5%)
8	Trust	As I went through the stages of the game, I felt confident that I was learning.	3.79 (1.236)	1 (3.4%)	4 (13.8%)	7 (24.1%)	5 (17.2%)	12 (41.4%)
9	Satisfaction	I'm satisfied because I know I'll have opportunities to put things I've learned from the game into practice.	3.62 (0.979)	0 (0.0%)	3 (10.3%)	12 (41.4%)	7 (24.1%)	7 (24.1%)
10	Satisfaction	It is because of my personal effort that I can advance in the game.	3.55 (1.270)	3 (10.3%)	2 (6.9%)	8 (27.6%)	8 (27.6%)	8 (27.6%)

(*) Mean (standard deviation).

Source: Elaborated by the author

In addition to descriptive aspects, Table 2 presents basic statistics (absolute and relative frequencies, average and standard deviation) on the answers to the items of the digital game evaluation scale "Probability in Action", according to the subcomponent of the scale called experience user (students). The following aspects were considered: immersion; social interaction; challenge; funny; and competence.

Table 2 - Distribution of scale items for evaluating the user experience subcomponent

n	Subdimension	Propositions (Items)	Statistics (*)	Strongly Disagree	Partially Disagree	Neither agree or disagree	Partially Agree	Strongly Agree
11	Immersion	I temporarily forgot about my day-to-day worries; I was fully focused on the game.	4.03 (1.295)	2 (6.9%)	3 (10.3%)	2 (6.9%)	7 (24.1%)	15 (51.7%)
12	Immersion	I didn't notice time passing while playing, when I saw the game was over.	4.00 (1.134)	2 (6.9%)	1 (3.4%)	3 (10.3%)	12 (41.4%)	11 (37.9%)
13	Immersion	I felt more in the game environment than in the real world, forgetting what me was around.	3.48 (1.326)	3 (10.3%)	4 (13.8%)	6 (20.7%)	8 (27.6%)	8 (27.6%)
14	Social interaction	I was able to interact with other people during the game	4.14 (1.246)	2 (6.9%)	2 (6.9%)	2 (6.9%)	7 (24.1%)	16 (55.2%)
15	Social interaction	I had fun with other people	4.31 (0.891)	0 (0.0%)	1 (3.4%)	5 (17.2%)	7 (24.1%)	16 (55.2%)
16	Social interaction	The game promotes moments of cooperation and/or competition between the people who participate.	3.90 (0.860)	0 (0.0%)	1 (3.4%)	9 (31.0%)	11 (37.4%)	8 (27.6%)
17	Challenge	This game is suitably challenging for me, the tasks are neither too easy nor too hard.	3.31 (1.491)	5 (17.2%)	3 (10.3%)	9 (31.0%)	2 (6.8%)	10 (34.5%)
18	Challenge	The game evolves at a suitable pace and doesn't get monotonous – it offers new obstacles, situations or variations of activities.	3.38 (1.147)	2 (6.9%)	4 (13.8%)	9 (31.0%)	9 (31.0%)	5 (17.2%)
19	Fun	I had fun with the game.	4.10 (1.176)	1 (3.4%)	3 (10.3%)	3 (10.3%)	7 (24.1%)	15 (51.7%)
20	Fun	When interrupted, I was disappointed that the game was over (I wish I could play more).	3.86 (1.246)	0 (0.0%)	3 (10.3%)	6 (20.7%)	9 (31.0%)	11 (37.4%)
21	Fun	I would recommend this game to my colleagues.	4.41 (0.733)	0 (0.0%)	0 (0.0%)	4 (13.8%)	9 (31.0%)	16 (55.2%)
22	Competence	I would like to play this game again	4.21 (1.048)	1 (3.4%)	1 (3.4%)	4 (13.8%)	8 (27.6%)	15 (51.7%)
23	Fun	I managed to achieve the goals of the game through my skills.	3.90 (0.900)	0 (0.0%)	1 (3.4%)	10 (34.5%)	9 (31.0%)	9 (31.0%)
24	Competence	I had positive feelings of efficiency during the game	4.17 (1.002)	1 (3.4%)	1 (3.4%)	3 (10.3%)	11 (37.4%)	13 (44.8%)

(*) Mean (standard deviation).

Source: Elaborated by the author

Table 3 presents some basic statistics (absolute and relative frequencies, average and standard deviation) on the answers to the items of the scale to evaluate the digital game "Probability in Action" according to the learning subcomponent (short and long term).

Table 3 - Distribution of scale items for evaluating the learning subcomponent

n	Subdimension	Propositions (Items)	Statistics (*)	Strongly Disagree	Partially Disagree	Neither agree or disagree	Partially Agree	Strongly Agree
25	Short term learning	The game contributed to my learning in Probability	4.24 (0.704)	0 (0.0%)	0 (0.0%)	5 (17.2%)	12 (41.4%)	12 (41.4%)
26	Short term learning	The game was efficient for my learning in Probability, compared to other Mathematics activities	3.97 (1.085)	1 (3.4%)	2 (6.9%)	5 (17.2%)	7 (36.8%)	11 (37.4%)
27	Long term learning	The experience with the game will contribute to my performance in their training in Basic Education.	4.00 (1.000)	0 (0.0%)	1 (3.4%)	11 (37.4%)	4 (13.8%)	13 (44.8%)

(*) Mean (standard deviation)

Source: Elaborated by the author

6.1 Analysis of results by items

Here, the analysis of the results referring to each of the 27 items of the evaluation scale of the digital game "Probability in Action" was carried out, according to the perception of learning and experience when playing by 29 students aged 10 and 11 from a Brazilian primary school, 16 students (55.2%) were female and 13 (44.8%) were male.

The results presented in Tables 1, 2 and 3 were used, which show the number of cases tabulated for each item of the scale, in addition to indicating the averages and deviations obtained. In the case of means and deviations, they were calculated according to the scores obtained in each response or item on the scale.

Regarding the score established through the scale, each student assigned a number of points per item answered as follows: I totally agree = 5 points; partially agree = 4 points; indifferent = 3 points; partially disagree = 2 points e; strongly disagree = 1 point. It is noteworthy that the higher the score obtained in each item or in the sum of the items, the more positive the evaluation in relation to the game.

In addition, it is considered that the higher the average score attributed to each item by the group of students, the more positive the evaluation in relation to the game. The average score of the evaluation performed was obtained by assigning values from 1 to 5 to the levels of agreement on the Likert scale, with an average equal to 3 indicating equivalent agreement and disagreement.

6.2. Best rated items

There were 14 items with an average score above or equal to 4.0 and considered to have the best ratings, 4 (out of 10) referring to the Motivation subcomponent, 8 (out of 14) referring to User Experience and 2 (out of 10) 3) in Learning. According to the total results by items, it is highlighted that the best evaluated items, starting from each of the subcomponents are: 1) Motivation Subcomponent: 1.1) Item 6 - Relevance (The content of the game relates to another knowledge that I already had) with a score of 4.28; 1.2) Item 7 - Confidence (It was easy to understand the game and start using it as study material) with a score of 4.55.

It is indicated that the relevance and importance of probabilistic content is perceived, providing students with feelings of progress: 2) User Experience Subcomponent: 2.1.) Item 15 – Social Interaction (I had fun with other people) with a score of 4.31; 2.2.) Item 21 - Fun (I would recommend this game to my colleagues) with a score of 4.41.

In this subcomponent, it is indicated that the students consider it pleasant and fun to participate in the digital game "Probability in Action", in addition to awakening the feeling of connection with the other students in the group participating in the research, generating empathy, cooperation and competition: 3) Learning Subcomponent: 3.1) Item 25 - Short term learning (The game contributed to my learning in Probability) with a score of 4.24.

In this case, there is an indication that the students consider that the educational objectives of the activities related to teaching probability addressed in the digital game "Probability in Action" were achieved.

6.3 Worst rated items

It should be considered that all items were evaluated positively, based on the assumption that a score lower than 3 indicates a negative evaluation and equal to 3 neutralities. In this case, no score less than or equal to 3 was observed, confirming a positive evaluation of the digital game. In any case, the items with the lowest value and least positive stand out, namely:

1) Items of the "Challenge" dimension of the "User Experience" Subcomponent: 1.1) Item 17 (This game is suitably challenging for me; the tasks are neither too easy nor too difficult) with a score of 3.31; 1.2) Item 18 (The game evolves at an adequate pace and is not monotonous – it offers new obstacles, situations or variations of activities) with a score of 3.38.

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2) Items of the "Satisfaction" dimension of the "Motivation" Subcomponent: 2.1.) Item 10 (It is because of my personal effort that I manage to advance in the game) with a score of 3.55; 2.2.) Item 9 (I am satisfied because I know I will have opportunities to use things I learned from the game in practice) with a score of 3.62.

In the case of the four highlighted items, it is indicated that the students may have considered that the game may not have been as challenging and compatible with their skill level. Furthermore, it was not indicated that great importance and application of what was learned was revealed. These aspects can be explained by the time available by the researchers to carry out the activities through the pedagogical game and that it was carried out in just one moment in the classroom.

6.4 Response homogeneity

Another question to be considered comes from Estrada (2002) when he suggests studying the dispersion of the response, as a small dispersion indicates a large agreement. In this study there is homogeneity in the students' responses, as it appears that there is a small degree of data dispersion. This means that responses are similar across the sample of students, as standard deviations are relatively low in relation to means.

Based on the study by DeVellis and Thorpe (2003), it is highlighted that items with averages close to the extremes of the response interval generally have low variance, and because they vary within a short interval, they may have low correlation with the other items on the scale. However, in this study, even with the means of the items approaching the upper part of the scale, the variance was not affected. Furthermore, variance in response to a scale item indicates that the item is capturing a significant level of diversity among the respondent population (the 29 students in the fifth grade of elementary school).

Below are the three items with the highest degree of dispersion between 1.31 and 1.50, all of the User Experience subcomponent: item 17 – "Challenge" dimension (This game is suitably challenging for me, the tasks are not neither very easy nor very difficult), item 13 – "Immersion" dimension (I felt more in the game environment than in the real world, forgetting what was around me) and item 28 – "Immersion" dimension (I temporarily forgot my concerns day-to-day, I was totally focused on the game).

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Thus, it is indicated that there are some different positions in relation to the item aimed at the challenge of playing, establishing that students have different perceptions or difficulties regarding the probabilistic tasks proposed in the game. The other two items indicate that there are also different positions regarding students being fully involved with the game, with a change in the perception of the passage of time, in addition to the feeling of being emotionally involved.

In this study, the degree of reliability of the scale responses was 0.907, which confirms the instrument's high internal consistency. In addition, the values obtained in each of the subcomponents of this study demonstrate that the reliability of the evaluation model is considered good for the subcomponent’s motivation (α Motivation = 0.848) and user experience (α User experience = 0.821), in addition to being acceptable for the motivation subcomponent (α Learning = 0.741). The reliability coefficient confirms the instrument's internal consistency.

It is observed that the three subcomponents of the scale (motivation, user experience and learning) are positively correlated with each other and with the total scale score (correlation is significant at the 0.01 level). In addition, only two items do not appear to be correlated with the total points of the scale, item 7 (referring to the Motivation subcomponent - Trust dimension), “It was easy to understand the game and start using it as study material” and item 23 (referring to the User Experience subcomponent - Fun dimension) “I was able to achieve the goals of the game through my skills”, which indicates that they do not present statistically significant aspects in the evaluation of the digital game “Probability in Action”.

The study indicates that, the higher the score related to an item or subcomponent of the evaluation of the educational digital game, there is also an increase, on average, in the score of other items or subcomponents, assuming a positive correlation or evaluation.

6.5 Analysis of global results

Once the results were studied by item, the attitude scale was analyzed using the total score obtained by each student, which can vary from 27 to 135 points. It is also noteworthy that, if all respondents had a position of indifference (grade 3 in the questionnaire), a score equal to 81 would be obtained.

Thus, it was observed that there were only 2 (6.89%) scores below this value, which indicates that the respondents' assessment of the educational digital game "Probability in Action" is positive, concentrating largely around the mode, which is 102, the median, which is 108, and

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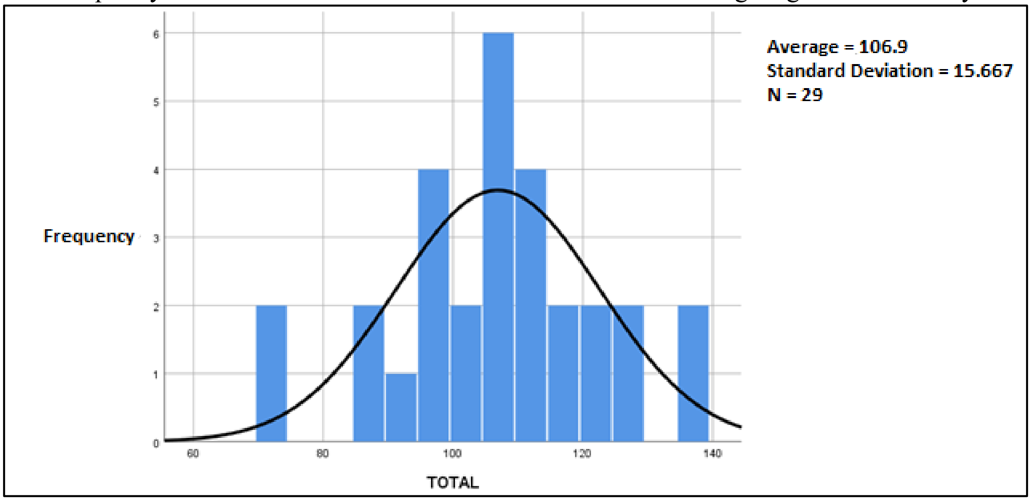
the mean, 106.9, as shown in the histogram (Figure IV), which corresponds to an approximately normal form of the frequency distribution of the total score.

Figure 4 - Frequency distribution of the total score of the evaluation of the digital game "Probability in Action"



Source: Output PSPP

If the histogram does not present inconsistencies with the normal distribution, it is recommended to evaluate the symmetry and kurtosis estimators, which represent aspects related to the shape of the histogram: shifted to the left/right (symmetry) or peaked/flattened (kurtosis); both measures approach zero when the data are normal. As these estimators are affected by sample size and extreme values, it is prudent to calculate the ratio of their values to the standard error of their estimates. In general, the value of the coefficient divided by its standard error must be between -1.96 and +1.96 in normal distributions (KIM, 2013).

The average value obtained from the scores is 106.9, considering that the lowest score corresponds to 72 and the highest to 135. In addition, as the standardized value of the asymmetry coefficient (-0.72) and kurtosis (0.2) is located between the limits [-1.96;1.96] was admitted within the limits of normality.

Finally, in the following topic, the final considerations of this study are presented, based on the theoretical framework presented, in addition to seeking to respond and meet the objective of the research in seeking to present quality of the game in support of teaching probability for the initial years of elementary education.

7 CONSIDERATIONS

According to Navarro and Van der Hoek (2007), Santos et al. (2008) and Savi et al. (2011) it is extremely important to evaluate educational games in their computational and pedagogical aspects, so that it is possible to validate the competence of these games in view of their objectives.

Considering that the evaluation of games has been concerned only with an evaluation focused on the interface, or only focused on the pedagogical aspects, this work carried out the evaluation of the educational digital game " Probability in Action", considering aspects of motivation, user experience and learning of probabilistic concepts in games.

With the results obtained through the analysis of the students' responses in evaluation to the educational digital game "Probability in Action", using a Likert scale, this game can be characterized as an option to support the teaching and learning process of probabilistic concepts to fifth-year elementary school students, making students feel in a playful and motivating environment.

There were some weaknesses that were perceived in the students' evaluation of the educational digital game, that is, students may have considered that the game may not have been as challenging and compatible with the level of their skills.

It was not indicated that great importance and application of what was learned was revealed. These aspects can be explained by the time available by the researchers to carry out the activities through the pedagogical game and that it was carried out in just one moment.

However, the proposition of using digital games to improve attention span constitutes an intervention that aims to guarantee better learning conditions, thus favoring the inclusion of students. The use of technologies in education has a pedagogical impact on the teaching processes and on the factors that interfere with the quality of learning (TRINDADE; MOREIRA, 2017).

The evaluation carried out allowed us to perceive that the educational digital game "Probability in Action" presented positive results in the scenario in which it was evaluated, since in the students' responses of the subcomponent "Motivation" we perceive the relevance and importance of the probabilistic content, providing opportunities for sensations of progress.

This perception of the students participating in this research converges with Keller (2009), when indicating that the educational proposal must be consistent with its objectives, that it manages to connect the learning content with its professional or academic future. It should still represent the level of association that students can perceive between their prior knowledge and new information. In addition, the game also allowed to provide successful experiences in the use of school supplies resulting from the students' own ability and effort, influencing the students' persistence.

For the subcomponent “User Experience”, the students consider that it was pleasant and fun to participate in the digital game “Probability in Action”, in addition to awakening the feeling of connection with the other students in the class participating in the research, generating empathy, cooperation and competition.

For Takatalo et al. (2010), involvement with other people is an element of fun in games and is related to the feeling of sharing a certain environment and having an active role. The game can create opportunities for players to compete, cooperate and connect, providing feelings of fun, pleasure, relaxation, distraction and satisfaction (POELS et al., 2007).

In the case of the “Learning” subcomponent, the students consider that the educational objectives of the activities related to the teaching of probability, addressed in the pedagogical game “Probability in Action”, were achieved, specifically in relation to short-term learning. For Moody and Sindre (2003) it is considered that the effectiveness of a short-term learning activity is determined by achieving its objectives (in terms of knowledge, skills and attitudes). This short-term learning influences long-term learning and can generate in the individual a perception of the usefulness of what was studied (probabilistic concepts) going beyond the scope of the discipline and contemplating its use in everyday life.

Thus, digital games can be used to teach and learn, at the same time as being inclusive, implying thinking about their use as a counterpoint to traditional methodologies when they cannot homogenize students, and as a tool capable of leading students to overcome challenges in relation to their own learning.

In this sense, it is considered that the evaluation process adopted in this work can be replicated or adapted to other educational games from different educational contexts or levels of education, through specific adaptations, even if they are from different areas of knowledge, such as, for example, the statistics.

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