DescubraMatemática: A game for learning trigonometry and flat geometry in high school

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Abstract—This paper deals with the development and validation of a game as a learning object for the 3rd year high school mathematics discipline, with the contents of Trigonometry and Flat Geometry. The research deals with the analysis of the perception about the perspectives perceived by the high school mathematics teachers of Cedro, Ceará. The development is based on the concepts of Digital Game Production, learning techniques through Digital Learning Objects in Mathematics and on the benefits in the school environment. As a result of this research, it was found the ability of DescubraMatemática to be used by teachers to assist the process of teaching and learning of the contents addressed and cognitive development of students.

Keywords-game; learning; mathematics;

I. INTRODUCTION

Currently it is perceivable the presence of games in people's daily lives, especially among adolescents. The game, although in its essence, being a way to escape reality, does not preclude its pedagogical approach, being used as a tool that helps the development of the teaching and learning process. [?] conceptualize the game as free, profit-free, timeand / or space-bound and rule-based. But this concept is not absolute, the game being an abstract element can be modeled so that its approach positively influences the user experience.

Mathematics carries with it a stigma of high difficulty, not because it is difficult, but because people unconsciously attribute this difficulty to mathematics for lack of knowledge [?]. This problem has been dragging on over the past decade and is perceived in below-average performance indices, as diagnosed by Todos pela Educação [1], through the analysis of the Basic Education Assessment System database. (Saeb) of the Ministry of Education (MEC), which seeks to assess and monitor whether students are developing in the school year.

Among the contents that must be prioritized in order to achieve satisfactory capacity and skill and that is addressed in this work, the following stand out in the theme of space and shape: Associate a simple geometric solid with a given usual planning; Problem solving involving the Pythagorean Theorem to calculate the measure of hypotenuse from textual information and figures; Determine the measurement on one side of the triangle using trigonometric rules and ratios. In recent times, the Educational Institutions have been worrying about the Digital Inclusion of the students and inserting them in this environment through investments when acquiring and making available resources that make accessible tools that help in the performance of the learning process.

Thus, we questioned the need to seek new strategies to provide learning in order to elevate the student development process, such as the game as a learning object. The general objective of this work is to develop and validate a digital game to assist the teaching process learning mathematics content of the 3rd year of high school.

II. METHODOLOGY

This section discusses the materials, methods, and tools used in the development and validation process of the Math Path game. This research was submitted to the Ethics and Research Committee of the Federal Institute of Education, Science and Technology of Ceará (IFCE), obtaining approval and being registered with the CAEE 11405319.9.0000.5589.

1) Research Characterization: This research started with a bibliographic research being developed with the help of the content indexing platform through the platforms: Google Acadêmico¹, IEEE Xplore Digital Library², Portal SBGames ³, and in online collections like in the University Virtual Library ⁴. To obtain the works, the following keywords were used in the search: with keywords: "Games for Mathematics", "Games as a teaching tool" and "Digital games for learning".

As a form of validation, an experimental study was conducted to analyze teachers' perceptions in an objective and subjective manner, implicitly characterizing the research as quali-quanti.

A. Research Subjects

Five teachers were selected as subjects of this research, who met the following inclusion criteria:

¹https://scholar.google.com.br/

²https://ieeexplore.ieee.org/Xplore/home.jsp

³http://sbgames.org/sbgames2019/

⁴https://ifce.edu.br/proen/bibliotecas/biblioteca-virtual-universitaria-bvu

- Teaching math discipline in high school Cedro-CE;
- Have at least 3 years of teaching experience;

B. Collection Instruments

Among the data collection instruments, the questionnaire was chosen, divided into sessions and their items standardized by the 5-point Likert scale. The sessions present, in order:

- 1) The Informed Consent Term, which must be accepted to continue the research;
- Four questions addressing the didactic aspects of the game;
- 3) Four other questions about perceived technical aspects;
- 4) Optional data for result segmentation;

To construct the questionnaire, the Google Forms⁵ tool was adopted. In this work the data analysis and graph generation was performed through the software R, which was conceived by [2]. In addition to the R itself, the likert package was also used. ⁶ to generate the graphs based on the answers obtained through the form that had the Likert scale as alternatives.

III. DESCUBRAMATEMÁTICA

The DescubraMatemática emerged from an academic work for the Introduction to Digital Game Development discipline, with its development as a general assessment in the discipline. The purpose of the game is to be a learning object, relaxed and fun to help fix the content of geometry and trigonometry in high school. Regardless of the game's purpose, visual environments are designed to portray the general history of mathematics, chronologically displaying times and places that are important to its development.

1) General Game Features: At DescubraMatemática, systems and mechanisms based on intrinsic principles and characteristics have been implemented for a game to achieve its goal and arouse the desire to play in the players. To develop cognitive ability and quick thinking, time delimitation was used to motivate and challenge the player.

The character setting and selection system implements the concept of in-game freedom, where the player is given the power of choice to enhance or facilitate their experience. Finally, the ranking system, in which it is possible to visualize the best performances of the players, instigating the competitiveness and consequently motivating to improve and increase the level of knowledge of the approached content.

A. Game Screens

For the construction of the game's scenarios, it was necessary a conceptual analysis of the visual of the proposed environments, in order to add the concept of likelihood. The Stage shown in Figure 1 brings visual elements that refer to

⁵https://forms.gle/hzDRnCpw5jC8g3b78

the ambience of the real scenario, generating immersion in the player. The Egyptians were able to calculate the area of a cylinder from its diameter, and with their knowledge of area, they could also calculate the volume of the cylinder and the pyramid. Because it is the initial phase, it has fewer platforms that are arranged to facilitate first contact and prepare the player for the next phases.



Figure 1. Egypt Stage.

As noted in Figure 1, the menu has four items: Start Game, which is responsible for opening the name and character selection sub-screen and then starting the initial phase load; The Ranking button displays the ranking sub-screen, showing the best players for the shortest time. The Settings button displays a sub-screen with general settings such as song, name and difficulty. On the right side you can interact with a dynamic interface that allows the transition between the three items in the top menu. These items are responsible for organizing and displaying information that presents the rules, tips and explanations of the game, ensuring a better player experience.



Figure 2. Main Screen

The character choice screen shown in Figure 2 is displayed when the user from the Main Menu selects the Start Game option. This mechanism is responsible for updating the user name that can later be entered in the ranking system, in addition to the choice of your character, leaving the player who best suits the responsibility of the player.

B. Game unpredictability

The unpredictability of the game is the ability to dynamically generate and control elements such as position, riddles

⁶https://cran.r-project.org/web/packages/likert/likert.pdf¿.



Figure 3. Character Selection

and enemies, creating uncertainty throughout the session. This is a very important feature of the game's success, as stated by [3].

Present in most games, this feature becomes one of the important to achieve the central goal, which is to awaken knowledge, stimulate learning, and develop thinking in various situations.

IV. RESULTS

This section presents the results obtained from the analysis of the data collected in the questionnaire applied in the presentation and interview with the teachers. The discussions made here were based on the graph shown in Figure 4, which shows the degree of agreement of the teachers regarding the statements made. As subtitles, we have: "SA" as Strongly Agree, "A" as Agree, "N" as Neither Agree or Disagree, "D" as Disagree and "SD" as Strongly Disagree.



Figure 4. Likert questions

STATEMENTS MADE TO TEACHERS	
Identifier	Statement by respondents
P1	The DescubraMatemática shows itself as a relevant learn-
	ing object and can be used in high school math classes.
P2	The DescubraMatemática allows the development of stu-
	dent reasoning as a player.
P3	The math content of DescubraMatemática is consistent
	with the Common National High School Curriculum
	Base.
P4	I would use DescubraMatemática in my classes to enable
	my students to learn the content better.
P5	The DescubraMatemática it has an attractive and satis-
	fying design that motivates the high school student to
	explore the game content
P6	The DescubraMatemática features unpredictable features
	that allow the high school student - as a player - to feel
	engaged in discovering the scenarios.
P7	The tips in DescubraMatemática allow for better game-
	play, helping the player to continue through the levels
P8	The DescubraMatemática can be used in the school envi-
	ronment without any restrictions.

Table I

The statements present in the questionnaire are listed in Table 1, with statements P1 to P4 related to didactic aspects of the game and P5 to P8 related to visual technical aspects, seeking to analyze if the proposed game has characteristics capable of engaging students during and after the game. use of the game in the classroom.

In the didactic aspect, statement P1 had answers in agreement degree from 80% to totally and 20% partially by the teachers. Highlighting the ability of the proposed game to be a digital learning object that can assist the teaching and learning process in high school math-related content.

Statement P2 was totally 100% agreed by the teachers regarding the ability of the game to promote the development of the student's logical-mathematical reasoning. The development of logical-mathematical reasoning comes down to the ability to organize thoughts to solve problems, the exact point where DescubraMatemática stimulates throughout the game's progress. This evaluation was due to the game's characteristic of presenting dynamic elements such as randomly spread and time-limited riddles to the end of each phase, forcing the player to respond quickly to the riddles.

Statement P3 that dealt with the level of match of the game with the content present in the 3rd year of high school which is defined by the BNCC⁷ and statement P4 which aimed to find out if teachers would agree to use DescubraMatemática in their subjects. Both statements had a degree of agreement of 60% for fully and 40% for partially. As a consequence of the studies carried out in the BNCC document, the trigonometry and flat geometry content present in the game fits into the set of knowledge pertaining to the 3rd year of high school, allowing the teacher to use the game without the risk of presenting content outside the curriculum matrix of the school. subject.

⁷;http://basenacionalcomum.mec.gov.br¿.

Statement P5 sought to evaluate the perception of the visual concept employed in the game in the teacher's view and its impact, and statement P6 sought to evaluate the teacher's opinion regarding the unpredictability of the game, instigating the student's engagement in playing the game. DescubraMatemática. Both statements had a degree of agreement of 60% for fully and 40% for partially.

It is clear that the conceptual use of scenarios related to times and places important to mathematics added to the game the experience of immersing in these micro-worlds. However, the approach of a simple design concept in the production of DescubraMatemática required completely free resources, which limited the audio-visual elements of the game, which eventually impacted the visual details. Finally, it is clear that DescubraMatemática has the ability to achieve its goals by encouraging students to explore the scenarios and their dynamic components, as well as perform actions necessary to progress in the game.

The statement P7, which had 100% of the responses in full agreement by the teachers, is the result of the use of a friendly and simplified interface, allowing players to navigate the information clearly and objectively, as shown in the figures in Chapter. 4. The tips in the Main Menu, which provide players with an understanding of the gameplay regarding riddles, game event warning messages, and character movement mechanics.

Statement P8 sought to observe teachers' perceptions regarding the restrictions on the use of DescubraMatemática in the school environment. As a result of the agreement levels of 80% for totally and 20% for partially agree, with this assessment of teachers, it can be seen that the game is suitable for the school environment in which the 3rd year of high school is. and that the assets, soundtrack and screenplay are in agreement with the target audience.

In this context, it is possible to state that Descubra-Matemática is capable of assisting teachers in the teachinglearning process, and can be applied as a fixation exercise for the contents covered, being used as a digital learning object.

This research reaffirms what was exposed by [4], when it comes to the conclusion that the educational digital game can promote the development of the cognitive process, enhancing the absorption of knowledge about the content addressed in the proposal. These conclusions are taken from the eyes of the subjects of this research and have their limitations.

Thus, it can be seen through the eyes of the subjects of this research, that the digital game can be used as a learning object, provided it is produced with well-defined objectives and approach aligned with educational principles and concepts, which was also stated by [5].

V. CONCLUSION

The research sought to develop and validate the digital game DescubraMatemática about the didactic and technical aspects pertinent to a learning object through the teachers' view, which resulted in a satisfactory perception regarding the use of Digital Games as a tool to help in the teaching and learning process. learning.

The work was limited to the development and discussion of the perceptions of high school teachers about digital learning objects, with the game DescubraMatemática as a learning object. This made it possible to understand in general the acceptability of the game as a tool to assist in the teaching and learning process in the view of teachers, and its use within their methodologies and teaching.

For future work, research on students' perceptions of the game, as well as the influence of the game on certain subjects and math content, providing a comprehensive view of the potential of DescubraMatemática as a learning object. Also, it is expected to apply the game within a set period of time to study the gains students make from using it in the classroom context.

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