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More than playing, creating: The Contributions of game development in the mathematics teaching-learning process

Mais que Jogar, Criar: As Contribuições do Desenvolvimento de Jogos no Processo de Ensino-Aprendizagem de Matemática

Juliana Campos Sabino de Souza[1]

Mateus Gianni Fonseca[2]

ABSTRACT

Several research works discuss the use of games in the area of mathematics. However, while it is generally questioned about the contributions of playing in the educational act, this research is inclined to the process of creating the game. The purpose of this study was to investigate the potential of the elaboration of mathematical games based on the perceptions of twenty mathematics degree students at the Federal Institute of Brasilia. For this purpose, data were collected from rounds of conversation and participant observation. The need to study the content involved in the games that are elaborated, to set the timing for each game to be played and to think on how the interaction happens between the potential players were the main perceptions collected from the students regarding stages in the process of creating the game.

KEYWORDS: Mathematics, Ludic, Development of games, Mathematical games.

RESUMO

Diversas pesquisas versam sobre o uso de jogos na área de matemática. No entanto, enquanto em geral se problematiza acerca das contribuições do jogar no ato educativo, essa pesquisa se inclina ao processo de criação do jogo. Objetivou-se, portanto, investigar a potencialidade da elaboração de jogos matemáticos a partir das percepções de vinte estudantes da licenciatura em matemática do Instituto Federal de Brasília. Para tanto, roda de conversa e observação participante foram utilizados como instrumentos de coleta de dados. A necessidade de se estudar os conteúdos envolvidos nos jogos que são elaborados, a calibragem de tempo para a realização de cada partida e a reflexão sobre como se dá a interação entre os prováveis jogadores foram as principais percepções coletadas junto aos estudantes no que se refere a etapas perpassadas no processo de criação do jogo.

PALAVRAS-CHAVE: Matemática, Lúdico, Desenvolvimento de Jogos, Jogos Matemáticos.

[1] Federal Institute of Education, Science and Technology of Brasília - IFB, Campus Estrutural. juliana.souza@ifb.edu.br

[2] Federal Institute of Education, Science and Technology of Brasília - IFB, Campus Ceilândia. mateus.fonseca@ifb.edu.br

Introduction

Several advantages and possibilities to stimulate mathematics learning through games in school, more precisely in the classroom, are pointed out by many authors (FIORENTINI, MIORIM, 1990; LIMA, 2008; BARBOSA, CARVALHO, 2009). This ludic proposal can be seen, in turn, from different perspectives: (a) introducing; (b) consolidating; or, (c) revising a content. Besides, the game appeals to the motivation of the subjects involved - which in the case of mathematics, for example, can achieve results that reverberate in the decrease of anxiety in mathematics or in the stimulus to creativity in mathematics (FONSECA et al. 2018; ONUCHIC; ALLEVATO, 2011; GRANDO, 2000).

Obtained by teachers or, in some cases, created by them, several games are taken ready to play to the classroom. In this case, the purpose is that students appropriate the rules, mobilise the necessary knowledge and play. However, it is worth mentioning that the process of creating a game seems to have educational potential as well. Thus, considering that the learning related to the game can start since its conception and development, it allows to present the students another function for this educational resource - that they are not only players, but can also be creators. Creators, and then players of the instrument that assists them in learning.

Obviously, producing a game requires an initial intellectual capital, and this means that certain knowledge of the contents used in the process must be studied, learned or reviewed by those who are engaged in the task of creating the games. This is one of the main points in this article: to present another strategy to use games for mathematics teaching. It is noteworthy that the OECD (2018) highlights game as something to be included in the list of strategies of the mathematics teacher.

The study selected a sample of 20 students of the degree course in mathematics of the Federal Institute of Education, Science and Technology of Brasília (IFB) – Campus Estrutural. The research work tried to systematise the students' perceptions on the potentialities of the process of elaboration of a game connected to some mathematical content of high school. The objective was to investigate the potential of the elaboration of mathematical games by students who were now characterised as future mathematics teachers.

This work was presented in the Working Group "Mathematics education in the final years of elementary and high-school education" of the VII SIPEM - International Seminar on

Research in Mathematics Education, which took place from 04 to 08 November 2018 in Foz of Iguaçu - Paraná, this article being an extension of the work presented in this Working Group.

Use of Games as a Didactic Resource

From a ludic stimulus to learning, games can become important allies to the teaching-learning process (GRANDO, 2000; FONSECA et al., 2018). The stimulus can be as much related to the introduction of concepts as to the development (deepening) or review. Linked to this multiplicity of applications for the game, it can be elaborated for and with different levels of difficulty, which enables formulating and reformulating other concepts, as well as the reflecting on how previous knowledge and different applications connect.

Grando (2000) highlights some advantages and disadvantages of using games in the classroom. On advantages, the game is considered to be the developer of several aspects related to the learning process, such as cognition (by stimulating the player to reflect on the concepts approached by the game and strategies for solving problems), socialisation (in cases of game in groups that aim at interaction among the participants), motivation (challenge to reach a proposed goal, pleasure in learning), among others. This can be added to what the PCN brings when it points out that:

> The games are an interesting way of proposing problems, since they allow them to be presented in an attractive way and favour creativity in the elaboration of strategies of resolution and search for solutions. They propitiate the simulation of problem situations that require living and immediate solutions. (BRASIL, 1998, p. 46)

However, implementing the game in the classroom demands that the teacher prepares a specific planning, and this must be considered under the risk that, in case it is not carried out properly, the students will not understand the real objective of the task, therefore, they will play just for the sake of it - which is one of the disadvantages Grando (2000) points out.

Each game must present clear learning objectives (BRITO, 2005), what is expected from its insertion in the classroom, as well as the timely moment for its use. Therefore, teachers should be prepared, when implementing a game in their classrooms, and not think that just taking the game to the class will suffice to promote an environment filled with ludic learning. Another disadvantage is that using games may require greater teaching planning in terms of space and time.

Considering that the use of games aims, among other functions, at the learning of mathematical content, they can be given to the students not just to be played but that the

students, by constructing the game, can review the mathematical contents already introduced in class.

In view of these considerations, "the game is not simply a 'pastime' to distract the students, on the contrary, it corresponds to a deep requirement of the organism and occupies an extremely important place in school education" (TEZANI, 2006, p. 1), therefore, we insist, it must be used by the teacher with planning, always aligning the use of the game with the learning objectives. It is an entertainment that also generates knowledge (GUZMAN, 1986).

It is worth considering that, from this perspective, the use of games in the classroom can be considered as an active methodology, since this includes "activities that lead students to think constantly about what they are doing, with access to different sources of information that could assist them in the task "(BERNINI, 2017, p. 105). It can be considered as an active methodology, since the students become the centre of their learning process, while the teacher acts as a counsellor, proposing situations that stimulate this process.

Martinez (2014) and Brito (2005) affirm that to use the game one must reflect on its role as a strategy for learning, so one has to be objectively clear what students are expected to learn with the game, analysing the moment and content that will be worked, questioning the purpose and time of working with this game. For this reason, this article intends to analyse the potential that the game can offer to the process of mathematical learning during the elaboration phase.

Thus, to reflect that another strategy for the use of the game in math classes is concretised in the provision of space and time for students to develop the games themselves that will be played by their peers. Encouraging them to see themselves as creators, not just players, can help them take another look at the material produced, and thereby enhance their critical and creative perceptions. It can still be useful to get even more involved with the task.

Whether for a given content or a subject of free choice of the student, the teacher can, according to this strategy of working with the game, request that students develop their own game, after all, a practical class where students will create rules, select contents and make the material can become a moment that favours learning. To motivate them in the elaboration of games, the materials they developed could be made available to the school so that their peers could also play and learn.

This perspective indicates there is room for the teacher to stop being the centre of the learning process and for the students to assume the role of protagonists, who, besides being players, also become the designers and creators of a game. Thus, the students can act actively

in the elaboration of the game, since its conception to the organization of the material. Moran (2015, p. 34) points out that:

> if we want students to be proactive, we need to adopt methodologies in which they engage in increasingly complex activities where they must make decisions and evaluate outcomes with the support of relevant materials. If we want them to be creative, they need to experience innumerable new possibilities to show their initiative.

To propose didactic situations that favour learning is one of the points that configures the teacher as mediator of the learning, which offers more space to the students, who become leading actors in constructing their own mathematics understanding.

The experiment reported in this article counted on students of a degree in mathematics, that is, future teachers of the area. Our choice was based on two factors. We sought: (a) to understand how students of this level would act in the dynamics of game development, although they can demonstrate, due to their ongoing formation, a greater concern with the intentionality of the educational act; and (b) to systematise findings, and thus foster specific literature, to subsidise replicating this research in the area of basic education, since it is believed that the task of elaborating games can stimulate the students, making them delve deeper into the content, develop autonomy and creativity, while performing a collaborative work with potential in learning from their peers.

Method

This is a qualitative research aimed at collecting/registering impressions of 20 undergraduate students in mathematics at the Federal Institute of Education, Science and Technology of Brasília - IFB when in a process of elaborating and constructing didactic games. An initial task was proposed as a driving force for the activity of these students who composed the research sample: Elaborating a mathematical game involving some content of high school curriculum. The theme for the games was not defined in advance intentionally, so that students could choose which content they would like to approach.

It was a task of immersion of the students in the construction of mathematical games, and for that reason, space was offered so that they lived the dynamics of thinking in game since its conception and thus favour the collection and the recording of the impressions that they showed during this research.

Aiming to offer a minimum background before students had access to the initial problem, the group was engaged in a brief discussion about games in mathematics teaching to clarify any doubts and present examples of games and their potentialities. Then, the students were separated into groups of 6 or 7 members planning and executing their games.

For the construction to be validated by the fellow members of the sample, each author group presented their proposal to the other colleagues. It is worth emphasising that, aiming at the interaction between the groups and validation among the peers, a moment of culmination of the games was offered at the end of their construction. Thus, each group could also play the proposals built by the other teams. These phases served as a means of peer validation of the games they created, so that each group was able to offer different feedback to colleagues in order to improve their proposals.

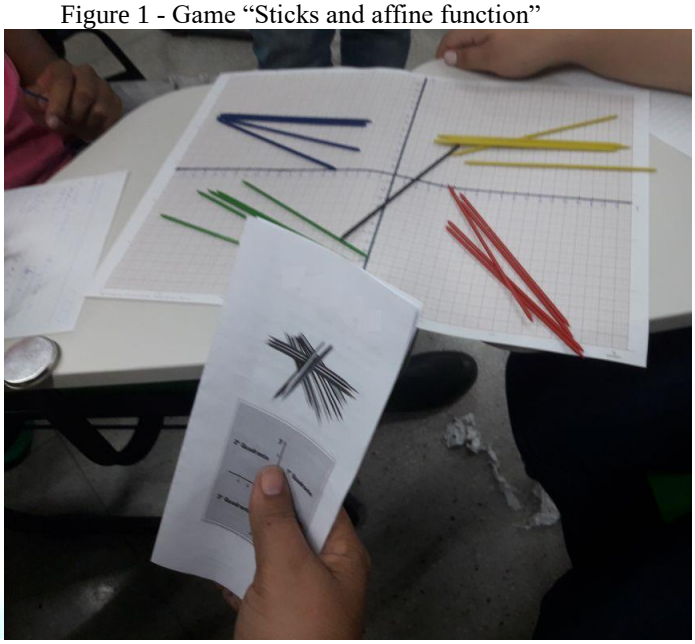
As tools for collecting and recording data from this research, the following were adopted: (a) rounds of conversation; (b) participant observation. The first one was used to collect the perceptions of the students, in groups, at that moment, after experiencing a period of planning and construction of a proposal of a mathematics didactic game, regarding the experience acquired, the potential learning that the game can offer and other considerations. To capture their speeches during the rounds of conversation and other considerations uttered throughout the period of construction of the games, the speeches, conversations and other forms of communication were registered. Participant observation was performed throughout the study period and reinforced the findings extracted from the rounds of conversation.

Game Development: Results and Discussion

The team, divided into groups, produced three games: (a) "Sticks and affine function"; (b) "Affine war"; and, (c) "What is the chance?". The following is a brief introduction to each of these:

(a) "Sticks and affine function": The group was inspired by the traditional game "Mikado" or "pick-up sticks". A checked mesh represents a Cartesian plane and players must drop the sticks on it. The player must choose a stick and define the 1^{st}-degree function that passes through its projection on the mesh. Only after the player gets it right, he/she can remove the stick from the plane and count the score, which is associated with the colour of the stick.

Figure 1 - Game “Sticks and affine function”



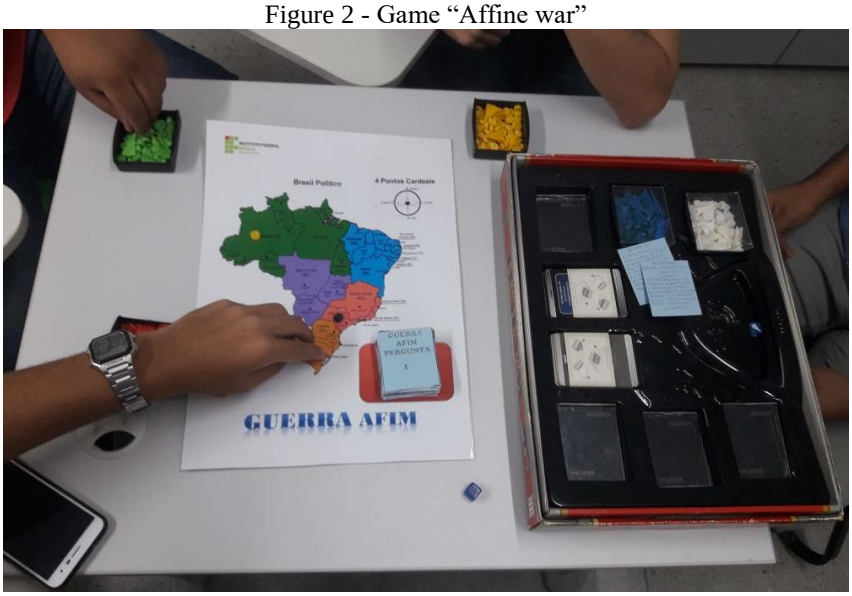
Source: Researchers Archive

In this game, the group of players must have a previous knowledge of 1st-degree functions and/or analytical geometry, because they must elaborate mathematical laws that describe the curve of a graph, which is now represented by the projection of the stick on the mesh. It is worth mentioning that the game should be offered to students who know, albeit minimally, about the subject. Planning the application of the game is a key point for the insertion of activities like this during class (MARTINEZ, 2014; BRITO, 2005).

The sticks may fall in different ways on the mesh, so that it becomes unfeasible to construct a template for the game. However, neither is a game that depends exclusively on the teacher's participation, because, as the stick can only be removed after their setting the function right, the opponents must also construct their answers to confront the player of each round - which contributes to self-regulation between peers as well as peer learning.

(b) "Affine war": This group also sought inspiration in a popular game. It was based on the strategy game called WAR. An important adaptation was made so that the game could be operationalised in the classroom: instead of using a world map, only a map of Brazil was adopted - which contributed to fit the timing of the game within the classes. The mathematical content used as reference for the elaboration of this game was also affine functions.

Figure 2 - Game “Affine war”



Source: Researchers Archive

The idealisers sought to combine a popular game among teenagers to rise greater interest among the players. The reduction of the world map to the Brazilian map was to adjust the game timing, which, in theory, would be applied during the class time, that is, about 50 minutes - and that is one of the variables cited by Grando (2000) when he points out the advantages and disadvantages of the game.

(c) "What's the chance?”: This is an unprecedented game, inspired only by the idea of board games. There is a trail of problems proposed in the game that are related to probability.

Figure 3 - Game "What's the chance?"

Source: Researchers Archive

Although probability is a subject that many find difficult, it is also content that arouses interest. Especially because it is applicable to different everyday situations and connected to

subjects such as soccer, prizes in sweepstakes and other situations. With the use of simple probability, this game can be addressed to audiences of different ages and school grades. Using everyday themes is also often encouraged when advocating current teaching strategies (OECD, 2018).

Some results were found from the observation participants. Although one group has been more organized than the others, students generally perceived the need to think of three topics specifically: (a) content; (b) objective; and (c) target audience.

The problem initially offered was 'ordering' the creation of a math game for high school students. Thus, the purpose of the initial task should be aligned with the curriculum of that school stage, which led them to consider the level of questions and the appropriate language according to the target audience. At the same time, the concern with the time required for the games was also a demand identified by the groups that made the team choose, as in the case of the game “Affine war”, the map of Brazil instead of the world map. The adaptation of the game to the scenario that would be applicable is in line with what theorists of this area defend about the proper planning for tasks like this.

A noteworthy fact is that the students who created these games realised that they should treat the content before designing the game. The didactic transposition was necessary for them to conceive games, that is, the ability to convert 'pure' academic knowledge into something more meaningful and tangible, even entertaining. And to carry out the transposition, more studies of the same content were undertaken - a fact that was perceived by the observation and evidenced during the round of conversation.

On the round of conversation, students reported that they had to study the content of the games to develop them, which reinforces that they had to learn/review math content for the creation of the respective games. This reinforces that the game elaboration requires that creators know the specific mathematics contents. When elaborating a game to learn a content one must know it, reflecting on which topics of the content the game will address.

In the games "What is the chance?" and "Affine war", players had to draw some cards with problems to solve to be able to continue playing. This fact will be analysed in two perspectives: the students who created the games and the students who will play them. The creators of the game had to select and review the questions, thus having to demonstrate knowledge of the selected content.

From the perspective of the students who will play the game, they must solve the problems/challenges proposed. And, in this sense Grando (2000, p. 33) points out that "both the game and the problem solving are impregnated with content in action and, psychologically, they involve thinking, cognitive structuring from the conflict generated by the problem-situation ".

Finally, it seemed to be a consensus that enchantment is one of the items for the game to work well and fulfil the purposes for which it was created, and that one should work with mathematical contents without letting the game lose its entertaining aspect (GRANDO, 2000; LIMA, 2008). The benefit of the game for both parties was also pointed out by the students participating in the research.

Thus, we can highlight two main points of the round of conversation: an activity like this allowed the perception that when subjects are involved in the development of a game, several concepts are mobilised. In this way, who develops the game also learns; this way of working games enables the stimulation of group work, creativity and collaboration between the peers in generating knowledge.

Participants in the research also cited as relevant the stimulus that the game provides in relation to several other skills besides mathematical knowledge, such as group work, creativity and peer collaboration. These characteristics are also highlighted in the literature, also underscoring autonomy, socialisation and motivation (GRANDO, 2000; MARTINEZ, 2014; LIMA, 2008).

To ratify the perceptions extracted from the students' speeches, it is worth noting that during participant observation the students' behaviour was of involvement. In practice, all team members seemed to be engaged in the task and put forward their ideas for the betterment of the game. It was not enough to be a good idea, but it had to be appropriate to the context, objective and target audience.

The last 2 games mentioned above can be adapted to other contents simply by changing the cards with the mathematical problems. Thus, it remains to be suggested that these can be used to work on other mathematical contents and can also be used in an interdisciplinary way when placing cards with questions that involve diverse contents that students are studying or have already studied.

It should also be stressed that the teacher, when proposing a game or the elaboration of a game in the classroom, must define well the learning objectives, having in mind: What are

the students expected to have learned after the elaboration of this game? When is the best time to use it? What does this activity favour in student learning?

In this way the game, or its creation, has a pedagogical objective, that is, the students are not playing it just for the sake of it, but rather it is a learning strategy used appropriately considering its potentialities, which demands that the teacher wanting to use games in the classroom reflect and plan their use in advance.

Final considerations

The participants of the research experienced the dynamics of game design and development and were able to learn 'by doing', thus enhancing their training regarding the pedagogical practice of using the game under another perspective, not only in the role of being played but also in the role of being developed.

It was possible to perceive that the students who developed the game considered possible ways to approach a mathematical subject in a didactic way that assisted the student's learning in relation to the content being focused.

It should be emphasised that for the development of a game, it is necessary to have knowledge of the mathematical content that is being addressed in the game, in this way, to elaborate a game the students -regardless of the level of school they are attending- must have knowledge of the content. So, proposing that students make games is a way to encourage them to learn the content. Besides, it is necessary that they review the content, thinking in a creative way on how it can be presented in a game form to the other colleagues in class.

The use of games since their conception seems to be a great ally of the mathematics learning process, since it brings together conceptual, motivational and creative aspects. Therefore, the game can be worked in the classroom not only for students of basic education to play, but also for them to create games, because the creation also stimulates the learning of mathematical content.

It was decided that the degree students would analyse the potential of a game as a way to learn and/or deepen a mathematical content so that they, future teachers, could perceive that they themselves learned the content addressed in the game in the production process, so they understood that their students would also learn through this proposal. From this practical experience, these students are expected, after completing the course, to use this resource, elaborating a game as a didactic learning tool, with their future students.

We understand that this research has limitations regarding generalising the findings, since it was conducted with only one group of students. However, it contributes to the reflection - resulting from the research- on the potentialities of the games when inserted in mathematics pedagogical practices at different school levels. Other points still lack further empirical investigations that demand more research, such as (a) verifying to what extent the game can motivate the students in mathematics; (b) evaluating the self-concept of the students who learn from the game and their relation to mathematics; among others.

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