Digital games, cognitive skills, and motivation: children's perception in the school context

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Abstract

In addition to entertainment, games have been recognized as enhancers of cognition and associated with increased motivation in the school learning context. The possibility of immersion and active player participation is considered a distinguished aspects of game design. Therefore, this study proposed the application of Brain School's digital games using tablets during a school year, with weekly interventions of 50 minutes in a class of the second year of elementary school. Twenty-five students were analyzed with an average of eight years old. At the end of the interventions, the evaluation was carried out through individual interviews. The results revealed that most of children felt motivated to participate in the games activities. However, there was no association between level of motivation and cognitive skills investigated (attention and problem solving), nor between preferred games and cognitive skills trained. However, qualitative data showed that children liked using games and acknowledged that the activity contributed with the exercise of their abilities. In general, this research contributed to reinforcing the importance of the diversification of methodological strategies which include the use of digital games in education.

Keywords: learning; school; executive function.

1. Introduction

This paper aims to discuss the role of digital games to improve cognitive skills and their potential motivator for the engagement of children in school. The interactive and playful characteristics that make games enjoyable experiences, as well as the way in which the proposed tasks and actions exercise aspects of cognition, are highlighted.

The interaction with digital games may constitute experiences that enhance cognitive abilities. Studies demonstrates that games can offer contributions to the development of functions directly linked to school learning (Mattar, 2010; Ramos & Melo, 2016), to the exercise of mathematical skills (Neto & Fonseca, 2013) and Executive Functions (Ramos & Segundo, 2018).

The contributions of digital games to cognitive development and learning are clashing with the disparities and resistance to the integration of digital technologies in the educational context (Ramos, 2013). Theoretical clashes, beliefs, demands for teacher training and lack of infrastructure are the main problems related. In general, there is a gap between what children consume and produce in their daily lives and how they experience school (Ramos, 2012).

Regarding the integration of digital games at school, several studies evidence them as motivational resources that stimulate children in their learning processes. Digital games can help in the development of new knowledge, increasing the possibilities of learning in a fun way and helping in the motivation of the children (Neto & Fonseca, 2013).

Considering these aspects, we define digital games, the exercise of cognitive skills and motivation, highlighting an intervention carried out in the school context using digital games integrated into the daily routine of the classroom. The results presented are based on the perception of the participating children about their motivation and the exercise of cognitive abilities such as attention and problem-solving ability.

2. Theory and related work

The context of digital games has motivating and fascinating elements which enable the satisfaction of desires through sensations and immersions (Ramos, 2012), as well as enable the player to be the protagonist in the development process through the participation and interaction of individuals (Murray, 2003). Immersion is characterized as a feeling of involvement in a strange reality that may cause sensations in the player and the gratifying ability to take meaningful actions and see the results of one's own decisions and choices (Murray, 2003).

Digital games share characteristics of analog games, but differ mainly by interactivity, interface, and immersion. In general, a game is "a system in which players engage in artificial, rule-defined conflict that implies a quantifiable outcome" (Salen & Zimmerman, 2012). Digital game is considered as playful activity in a series of actions and decisions limited by the rules and the game world that result in a final situation (Schuytema, 2008).

To summarize, the characteristics of the game Huizinga (1996) consider that it is "a free activity, consciously taken as 'non-serious' and outside the usual life, but at the same time capable of absorbing the player in an intense and total way".

Digital games are characterized by the following structural elements: rules, goals or objectives, results,

feedback, competition, challenge, interaction, and representation or plot (Prensky, 2012). The objectives and goals of a game are highlighted, which have the function of motivating the player and guiding the measurement of their performance, indicating how close you are to achieving the goal (Prensky, 2012).

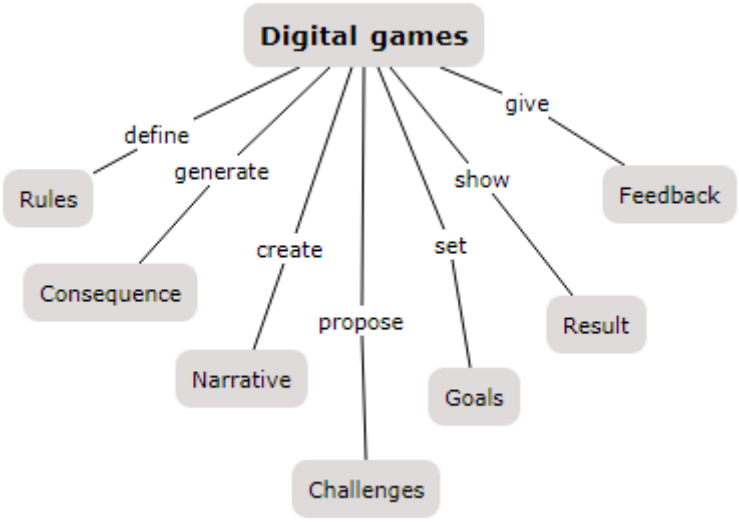

Figure 1. Game Character Scheme created with the Cmap Cloud.

The characteristics of digital games described by various authors (Mattar, 2010; Prensky, 2012; Murray, 2003; Salen & Zimmerman, 2012), as observed in Figure 1, can be related to player actions or player-game interaction, resulting in numerous possibilities which generate rich experiences. These characteristics assume the attention and focus of the player to overcome the challenges. To do so, many cognitive skills are involved in the player's action, based on mental processes such as memory, perception, reasoning, language and problem solving (Ramos & Melo, 2016). Cognitive abilities can be understood as the capabilities that make the subjects competent and allow them to interact symbolically with the environment it is in (Gatti, 1997). This way, games have been proposed for the improvement of cognitive abilities.

Among the diverse game types, we highlight the cognitive games that are used to provide experiences that enhance cognitive skills. These games "may be presented in different formats. They are generally simple games and have increasing levels of difficulty and can also replicate board or challenge games using the digital media" (Ramos, 2012).

Digital games have resources that effectively motivate learning in an intense way, contributing to what is called a "culture of interactivity", in which it is possible to participate actively in the process of acquiring new knowledge (Mattar, 2010). In addition, games have a high capacity for fun and entertainment, encouraging and motivating different learning through environments that generate curiosity, interaction and fantasy (Hsiao, 2007; Balasubramanian, Wilson, & Cios, 2006). Cognitive games exercise significant aspects related to cognition. Games challenge the player to use elements such as logical reasoning, memory, attention, problem solving, among others, converging aspects of pleasure and joy in digital games (Ramos, 2013).

Among the principles of learning in game designing, there are some aspects to be considered. The "interaction" happens when the player makes decisions and acts, receives feedback and new problems, and the game develops to the player's actions (Gee, 2009). The "production" refers to when the players are producers and participate in the game flow, because each player can follow different trajectories. The game

can be customized according to the player's style of playing and learning, which is called "customization". There are different difficulty levels, different ways to solve a problem, and one can choose different attributes for the characters. In good games, the "order of challenges" is present in such a way that connects one challenge to the other, leading the player to formulate hypotheses to solve problems efficiently; "challenge and consolidation" - the games offer a set of challenging problems and their solution becomes automated. After it, new problems are presented requiring the player to rethink and modify the solution; systematic thinking - games encourage thinking about the relationships that are established between events, facts, abilities and on the consequences of each action (Gee, 2009).

Motivational aspects related to teaching and learning processes have been discussed in different scientific contexts, as well as research that relates motivation using digital games in education (Savi & Ulbricht, 2008; Alves & Battaiola, 2011). In this perspective, motivation is a result of the individual's desires and needs (Spector, 2006). In addition, it can be understood as an "objective-directed action, being self-regulated, biologically or cognitively, persistent over time and activated by a set of needs, emotions, values, goals and expectations" (Salanova, Hontagas, & Pieró, 1996).

Motivation in individuals may involve aspects that guide the achievement of objectives and activate certain behavior (Tapia, 1999). In this sense, we can highlight two types of motivation: intrinsic motivation, which refers to the individual's internal motivations; and extrinsic motivation, which refers to external motivations (Huertas, 2001. Digital games can influence the motivational aspects related to learning, because games have favorable contexts for the understanding of intrinsic and extrinsic motivation, such as scores and feedbacks (Katz *et al*., 2014).

The success of using digital games for cognitive enhancement can be evidenced in several studies. Researchers in Scotland (Miller & Robertson, 2010) proposed an experiment with 71 children aged 10 to 11 years old attending elementary school for 10 weeks, during which activities were done with the children for 20 minutes daily. To provide a basis for comparison, children were divided into two groups: one that practiced with the digital game "Dr. Kawashima's Brain Training", and another that exercized for mental gymnastics on platforms similar to the game, but physical.

The evaluation was based on the tests used in the "Number Challenge", which verified self-esteem, mathematical skills, linguistic and social abilities, and the "Burnett Self Scale (BSS)", a self-administered method that identified opinions on aspects of students' academic and social lives. Results showed that, although both groups showed improvement in the post-test compared to the pre-test, the experimental group achieved more than twice the progress of the control group.

Another study (Castellar, Looy, & All, 2015) investigated the benefit of the use of digital cognitive games, involving 67 children with a mean age of 7 years, who participated in interventions for a duration of 3 weeks. Participants were divided into two groups in a random manner, half were instructed to regularly play "Monkeys Tales" while the other party performed mathematical exercises. The comparative results between the pre-test and the post-test showed that the use of the digital game has a positive effect on the students' working memory and perception of gratification.

A study in Sweden (Thorell, Lindqvis, Nutley, Bohlin, & Klingberg, 2009) involved 65 children aged 4 and 5 who used specific digital games for 5 weeks to work on oculomotor control and inhibitory control, while some of the children composed the control group and used other games. The comparative evaluation of

children included the application of six tests and the results indicated improvement in working memory and in higher levels of joy in children.

Finally, a research developed in Brazil with the use of "Brain School" (Ramos & Segundo, 2018) reinforces these results. A *quasi-experimental* study was carried out involving 100 children, divided into two groups: experimental and control. The experimental group participated in classroom interventions using cognitive digital games five days a week for six weeks. After the intervention period, both groups were assessed based on the application of psychological tests compared to the pre assessment. The results showed that the experimental group had a significant improvement in attention ($p < 0.05$) and cognitive flexibility ($p < 0.05$) when comparing the performance of both groups in the test, suggesting that the use of games can contribute to the enhancement of executive functions.

3. Material and methods

This study is characterized as a field research of mixed approach and is based on the participant's perception through semi-structured interviews. Interventions and data collection were carried out in a class of the 2nd year of an Elementary public school in Brazil, aiming to understand the perception of the participating children as well as their motivation regarding the proposed intervention and the development of their cognitive abilities.

The activities took place during a school year, with the interventions being carried out weekly and lasting the period of one class (50 minutes). The teachers agreed with the intervention and participated. The interventions used tablets provided by the school's Interdisciplinary Laboratory of Educators Training (LIFE).

Figure 2. Intervention in the classroom.

3.1 Participants

Twenty-five students were included, fifteen females and ten males. Participants were on average 8 years old. Parents received free consent terms allowing the children to take part in the intervention.

3.2 Instruments and procedures

The interventions were based on the use of the Games of the Brain School and took place in the room of the Interdisciplinary Laboratory of Educators Training located in the school. Twenty-five tablets were used, one for each child. During the intervention, two scholars were responsible for guiding the children and mediate any situation.

Figure 3. Screen of access to the games of the Brain School.

Brain School is an application that integrates digital cognitive games such as *Tetris, Genius, Looktable, Ladybug, Tangran, Connectome* and *Blocks*. It allows periodic assessments of attention, working memory and problem solving. In addition, provides the monitoring of individual performance in each game. For the intervention, games were previously chosen for each week, so that all the games of the application were played until the end of the intervention.

Table 1. Description of the objectives of Brain School games and cognitive skills.

Screen	Objectives	Cognitive Functions
	*Ladybug* Release the ladybug, moving blocks in only two directions, so that she can exit.	Attention to the initial conditions and arrangement of the parts. Planning and developing strategies (problem-solving) to move parts efficiently. Memorization of actions performed and solution hypothesis already tested.
	*Breakout* Destroy the blocks by bouncing the two balls and trying to keep at least one to complete the task.	Attention to follow the ball's movement. Analysis of the trajectory of the ball to elaborate strategies to hit the blocks (problem-solving).
	*Looktable* Find and click the numbers, scrambled in the grid, in ascending order.	Attention to track the numbers that complete the sequence. Problem-solving to justify the decision on how to better act. Operational memory to save the completed sequence.

	*Genius* Play back the growing color sequences that are displayed.	Attention to follow the presentation sequence. Memorizing the sequence for later reproduction. Depending on the amount of stimulus, a strategy must be used to reproduce the sequence (problem-solving).
	*Connectome* Connect two neurons, organizing the links between them, selecting and changing the position of the neurons to create the path.	Attention concerning the conditions and possibilities of solution. Problem-solving by developing strategies and planning actions to find the path in less time and with fewer clicks. Memorization of the strategies already used and the objective to achieve.
	*Tangran* Use all geometric pieces to complete the displayed figure.	Attention to discriminate the pieces and analyze the form. Problem-solving when develop hypotheses about the layout of the pieces to complete the figure. Memorization of the attempts already made.
	*Tetris* Move the pieces to draw lines and gain points, without letting the pieces reach the top.	Attention to analyze and discriminate each new piece. Problem-solving to determine the best movement to draw lines considering the possibilities.

Source: Ramos & Melo (2016).

The research was submitted and approved by the Research Ethics Committee (CAEE 67638216.5.0000.0121). After the weekly interventions based on the use of Brain School games, the children were interviewed individually. A semi structured roadmap was used as a basis to interview participants.

This script aimed to question participants about their perception of the project. They asked how often they played the games during the week besides the time in class. The motivation was checked using a Likert scale. The script then questioned which of the games the child had liked the most. After choosing the favorite game, three open questions were proposed: 1. *What did you like most about tablet activity using Brain School? Why?;* 2. *What did you learn by playing the Brain School games*? *Why*?; and 3. *What did you like least about tablet activity using Brain School*? *Why*?

After the open questions, the participant was submitted to filling in a scale of 1 to 3 (being 1 = “yes, much more”, 2 = “yes, a little more”, and 3 = “no, I continue as before”) on eight statements regarding attention, out-of-activity behavior, problem solving, and comprehension skills. The statements were: 1. I think better before doing any activity or solving a problem in school; 2. I got faster at problem solving; 3. I can more easily solve school problems and activities; 4. I try to solve more times something that I cannot solve easily;

5. I can understand better what the teacher asks me to do; 6. I understand better when I read something, such as texts and statements; 7. I can pay more attention in class; and 8. I try different ways to solve something that I cannot get right away.

The interviews were conducted individually with twenty-five children. The roadmap was filled in Google Forms and was applied by the interns after the end of the class. At the end of each interview, it was possible that the child also made some additional comments as wished.

4. Results

Considering the factors proposed and observed, the association between the level of motivation and the scores obtained was verified. From the sum of affirmations corresponding to cognitive abilities in total and in relation to attention and problem solving, it was observed that the average scores were higher in the higher motivation level, but this difference was not statistically significant (p> 0.05), as can be seen in table 2.

Table 2. Results of non-parametric tests for the level of motivation associated with scores of cognitive abilities.

	Level Low motivation Mean (SD) (n=4)	**Level High Motivation Mean (SD) (n = 17)**	**P***
Attention score	9,5(3,0)	11,3 (1,57)	p>0,05
Score problem solving	11,0(1,15)	11,41(1,17)	
Total score	20,5(3,41)	22,70(2,44)	

* Mann Whitney Test

Another factor analyzed referred to the game indicated by the child as the one that he/she liked the most and the scores obtained in the cognitive abilities considering previously the importance of affective elements in the involvement of the children with the proposals.

Considering the five games used in the activities, four were cited as favorites, especially the Breakout and Ladybug games. The results showed no influence on this preference in relation to the scores since close results were observed and the Kluskal Wallis test did not indicate a significant difference.

Table 3. Results of non-parametric tests for preferred games associated with cognitive abilities scores.

	Tetris (n=4)	**Breakout (n=6)**	**Ladybug (n=6)**	**Connectome (n=4)**	**P***
Attention score	10,5 (3,0)	11,6 (0,8)	10,6 (2,4)	11,6 (0,8)	p>0,05
Score problem solving	11,5 (1,0)	11,0 (1,6)	11,6 (0,8)	11,3 (1,3)	p>0,05
Total score	22,0 (4,0)	22,6 (2,4)	22,33 (3,2)	22,9 (1,6)	p>0,05

Nota.* Mann Whitney Test

Regarding the qualitative data, results show that the children interviewed liked the interaction with the Brain School games, when 47% (n = 10) pointed out that being in touch with digital games was what they liked the most, as illustrated by the lines: “I liked because then we had an electronic game moment in the classroom” (Interviewee 9) or even more generally “Play! Because I like to play.” (Interviewee 12). In addition, 14% (n = 3) of respondents demonstrated a preference for a specific platform game, 4% (n = 1) reported that they liked the presence of the challenge related to games, and 4% (n = 1) importance of the collaboration and to play together with the colleagues, being able to withdraw doubts with them about the games. Some children, about 14% (n = 3), did not know how to answer this question and another 14% (n = 3) did not like the Brain School.

When asked what they liked least about the tablet activities using Brain School games, about 38% (n = 8) of the children said they did not like it at all. In addition, 19% (n = 4) reported on the existence of difficult and boring games and 9.5% (n = 2) of the children commented on the tablet locking while playing. Other children interviewed, about 9.5% (n = 2), reported that they did not know how to answer this question, 9.5% (n = 2) did not like it when they wanted to change games and could not, 4.7% did not like the activities, and 4.7% (n = 1) reported that they did not like it when the activities ended.

Thus, when questioned about what they learned to play, the answers were diverse, as well as the following: mathematical learning, how to perform mathematical operations in the perception of 24% (n = 5) of children, as illustrated in the speeches: “I learned that I can connect things and also make an account that I had never learned” (Interviewee 14) or “I learned numbers. There is a little game that has to find the numbers” (interviewee 6). In addition, attention training was indicated by 19% (n = 4) of the children, the use of time in our favor cited by 4.7% (n = 1); overcoming obstacles and learning new paths that were commented by 4.7% (n = 1) children.

5. Discussion

From the analysis of the data found, the motivation was highlighted as a relevant aspect for the children researched. The children indicated feeling highly motivated in relation to the activity proposed with the use of digital games. Motivation allowed the children to engage with more interest in the proposed activities (Prensky, 2012), enhancing their involvement.

When analyzing the level of motivation self-referenced by the participating children during the interview stage, most of the children indicated to feel highly motivated by the activity proposed using digital games. This perception is in keeping with what authors (Huizinga, 1996) classify as typical of human nature, which is the historical tendency to voluntarily seek to deal with gaming activities. According to this same author, this occurs mainly because games give meanings to actions that transcend the activity performed, being these meanings built with the purpose of satisfying some tendency previously found in the player, along with elements of fun.

The results revealed that in general children had a high level of motivation, which according to Hsiao (2007) and Balasubramanian et al. (2006) can be justified by the understanding that digital games activate curiosity, interaction, and fantasy, encouraging and motivating players through the fun and entertainment that becomes constantly present. In addition to the fact that digital equipment is already part of the

children's daily routine, they are devices that are excluded from everyday life in the classroom.

It is observed that the average scores called attention and problem solving were higher in the higher motivation level, even though this difference was not statistically significant. According to Tappia (1999), motivation in individuals guides the achievement of goals and can activate certain behaviors. In this sense, the motivation provided by the play elements present in digital games affects the intrinsic motivation of the children contributing positively to the development of the proposed skills (Katz *et al*., 2014).

The mean scores for attention and problem solving were higher in the higher motivation level, but this difference was not statistically significant, indicating that the comparison between the higher and lower level of motivation did not influence the way the children assessed their cognitive abilities. This result may be in line with the studies of Katz *et al*.(2014), which, when affirming that games are effective resources for cognitive teaching and development, indicate the need to give greater attention to the selection of games and their elements, since they can induce distraction and therefore impair or reduce the performance of children in certain goals.

Regarding the preference for the use of games as a method of intervention, support is given to such a decision both in the gains pointed out in other articles by the choice of such path and by the motivational aspect offered by these devices - aspects that will be dealt with below.

Among its advantages, one that makes cognitive games especially viable in the school pedagogical environment is the way in which they measure the development of cognitive abilities in a playful way (Ramos, 2013). Thus, the child actively engages in the process of knowledge, making it more fruitful. The game, in turn, is a shortcut to "social, affective and cognitive benefits for the child and allows to work aspects such as imagination, imitation and rule", each game having a specific function and focusing on specific skills (Ramos, 2013). Through these activities, there is the provocation of a greater sense of cultural pertinence, motivation, information processing, data selection ability, involvement, interest, speed of data computation, self-esteem, mental arithmetic performance, cognitive processing (Miller & Robertson, 2010), memory visuospatial and verbal work (Thorell et al., 2009).

On the motivational criterion, the use of games in the improvement of executive functions is strengthened by the characteristics that allow the players to stay entertained and engaged. In his studies, Prins, Dovis, Ponsioen and Van der Oord (2011) suggest the use of strategic ludic elements such as thematic, feedback and animations instigate motivation and good performance in children players. In addition, the same study still infers that the formulation of games of simple adjustment profile allow small modifications to become possible in order to adapt the platform to the subjectivities of the target audience. Such an alternative is commonly used in programs with cognitive games, and, in turn, configures the structure of each game in the form of "problem games", to which Gee (2009) assigns repetitive and objective mechanisms.

Although the games used are classified by cognitive abilities and indicate that they work more strongly in relation to each other, the preference for a specific game did not show any association with the abilities assessed by the children. By interacting with a variety of games, children position themselves from different points of view and must use new skills and make those they already use more flexible. This is because "the way people solve problems depends, in part, on how they understand them" [26]. Thus, challenge games used during the project work together to motivate children to "think hypothesis, experiment, plan, test, perform calculations. In this way, they contribute to the development of logical

reasoning, planning, visual perception, and attention, for example." (Sternberg & Sternberg, 2016). Thus, the purpose of using cognitive games are put into practice by exercising cognitive skills in the face of challenging situations in order to perfect them, while maintaining its motivating aspect.

Considering these results, it is noticed that the children enjoyed the interaction with the digital games, which, according to Mattar (2010), are resources that effectively motivate the learning intensively, contribute to a culture of interactivity, where it is possible to participate actively in the process. Some children have highlighted the presence of the challenge as something motivating and that gives them a taste for the game. In this sense, motivation is the result of desires, needs and wants of an individual (Spector, 2006) and digital games can influence the motivational aspects related to learning since games have favorable contexts for understanding intrinsic and extrinsic motivation (Katz *et al.*, 2014).

Thus, games can facilitate the teaching-learning process and provide pleasant, interesting and challenging experiences, transforming them into a teaching strategy for educators, as well as being a rich instrument for the construction of knowledge (Grübel & Bez, 2006). In this way, children perceive learning as related to mathematics, sums, knowledge of numbers and associate to a specific digital game that makes up the Brain School.

Gros (2008) realizes that for games to be used for educational purposes, they must have well-defined learning objectives and teach the content of the disciplines to the players, or to promote the development of strategies or skills important to increase students' cognitive and intellectual capacity. In addition, the relationship between digital games and specific knowledge such as mathematics, has stimulated Neto and Fonseca's (2013) research that uses educational games as a means to stimulate the learning of mathematics, working with concepts learned in the classroom from a different perspective, in which students felt motivated and interested to exercise the knowledge of mathematics through digital games.

Another aspect highlighted by the interviewees was that the attention exercise was also recognized by the children, since the games exercise attention-related abilities, such as increasing the number of objects that are perceived simultaneously, selective attention and divided attention (Dye & Bavelier, 2010, Feng, Spence, & Pratt, 2007).

6. Conclusions

This research noticed that the motivational aspects are strongly related to the use of digital games in the context of education. Due to this aspect, most children indicated feeling highly motivated by the proposed activity with the use of digital Brain School games. The qualitative data reinforce this position, emphasizing the act of playing by the children as what they had liked the most in the interaction with the Brain School, to strongly emphasize the learning of mathematical knowledge.

In addition, studies indicate that interaction with digital games provides the enhancement of cognitive abilities linked to learning as well as the exercise of executive functions and mathematical skills. In this sense, cognitive skills such as attention and problem solving are related to higher levels of motivation. Many authors investigate this relationship between the use of digital games and the exercise of cognitive abilities, demonstrating potentialities in the field of education.

Thus, the school as a learning space needs to be attentive to the potentialities of the use of digital games. In

this way, the importance of this use is emphasized to favor more interesting and motivating learning, besides exercising the students' cognitive abilities, expanding the possibilities in educational contexts.

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