ISSN 2278-3091
Volume 9, No.4, July – August 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse336942020.pdf
https://doi.org/10.30534/ijatcse/2020/336942020

Modification of Logical Reasoning through an Informal Gamification Platform

Jhon Holguin-Alvarez[1], Aquila Montañez-Huancaya[2], Fernando Ledesma-Pérez[3], Juana Cruz-Montero[4] Fany Figueroa-Hurtado[5]
[1]Universidad César Vallejo, Perú, jholguin@ucv.edu.pe, jhonholguinalvarez@gmail.com
[2]Universidad Nacional de Educación Enrique Guzmán y Valle, Perú, amontanez@une.edu.pe
[3]Universidad César Vallejo, Perú, fledesma@ucv.edu.pe
[4]Universidad César Vallejo, Perú, jcruzmo@ucv.edu.pe
[5]Universidad Nacional de Educación Enrique Guzmán y Valle, Perú, silvanafigueroa2020@gmail.com

ABSTRACT

Informal Gamification based on video games turns out to be attractive due to its playful presentation, its motivational resources, and open access. This is important for the benefit of cognitive constructs such as logical reasoning, in the area of mathematics. Through this research, we implemented an experimental program based on the inclusion of the Plants vs Zombies video game as a cognitive modifier of reasoning. We developed the Gamification project through a pre-experimental design for six months. The sample consisted of 96 Basic Education students (M = 6.56 years of age; SD = 0.3). The pre-calculation test allowed us to contrast results between the pretest and posttest measurements. We obtained effective results in the dimensions of seriation, cardinality and cognitive conservation. The effects were much more decisive in conservation. These results allowed obtaining that the complexity of this game allowed to reduce the cognitive reload in the mathematical operations, as well as to increase the sustained attention in the development of logical reasoning tasks, and to achieve greater fluency in the operational calculation.

Key words: Cognitive Education, Cognitive processes, Gamification, Learning, Logic reasoning.

1. INTRODUCTION

Plants vs Zombies is a platform video game developed by the PopCap industry. It is included in Microsoft Windows, PlayStation 3, PlayStation 4, and is accessible for online games in multiplayer mode. This game has five levels of difficulty. The game is from the PopCaP Games brand, accessible to many by free download. The objective of the game is described in Figure 1, which is to eliminate characters (*Zombies*) that appear at the entrance of a house as a systematized mechanic of the game. These stimuli improve the player's cognitive ability at school through different playful movements: (a) orientation, (b) movement of objects, (c) reorganization of composite elements. It should be added that this video game also encourages addition and subtraction by obtaining the score per level. According to these benefits, we seek in this research to modify cognitive processes by influencing basic operations such as ordinality, cardinality and cognitive conservation.

Figure 1: The Plants & Zombies game, from the PopCap Game® brand.
Note: All rights reserved (lic. 2031-2).

Leisure media such as this type of video game are increasing in the market, although they are informal, they belong to different Gamification modalities, they can be considered in the educational context as an innovative means, motivating in the achievement of learning that is complex as it is the math. In the research on its teaching, different evidences have reported advances in the achievement of logical competences related to reasoning [1], [2], [3], [4], [5], [6]. In the Latin American context, there is still much to be investigated from teacher strategies for educational efficiency. The problem focuses on logical reasoning, which is considered as the competition for life. In the field of mathematics the problems are related to the understanding of digits, operationalization and the development of slogans. Given this, it is known that reasoning is the mental process that involves the development of analysis [1], [2], [6], so other operational processes intervene: (a) observation, (b) micro analysis, (c)

identification, (d) relationship, (e) monitoring, (f) verification. The problem is also found in that young people are deprived of attending the formal logical rules, which can be interpreted through the use of logic in the environment [7], [8], [9]. In this process of logical use of mathematical information, operative memory [8], [10], and short and long-term memory intervene.

For all that has been described, we find the need to involve basic Gamification processes to provoke the variables sustained interest and fluency in the initial logical reasoning processes. Taking into account that Gamification is the process of activation of mental processes, through the application of representative playful strategies in an experiential classroom [3], [5], [11], [12], [13], [14]. The proposals and evidence of some authors [15], [16], [17], [18], determine that these processes are based on missions that develop individual procedural work as well as cooperative work [19], [20], [21], [22], which causes concentration and attention in cognitive tasks. Although other empirical findings have shown that variables related to Gamification such as playful games have developed affectivity to complex cognitive tasks, due to the process of improvement that it exercises in the student [23], [24], [25].

It is necessary to note that the usefulness of basic operations such as exchanging quantities, varying them in the exchange of sums, as well as declaring more effective results, is due to the inferences caused by this type of Gamification based on games [24], [26], [27]. Given these perspectives, the research carried out proposed modifying the student's logical reasoning processes, through the use of a Gamification platform based on the Plants & Zombies video game.

2. METHODOLOGY

We work with the pre-experimental quantitative approach, in order to verify the modification in logical reasoning in a school group The study was framed in the quantitative approach, worked with a sample of 96 students from six to seven years of age (M = 6.56 years of age; SD = 0.3), from four educational institutions. They were all natives of the coastal regions of Peru. We consider a sample with low economic resources, in order to avoid bias in early reinforcement. With this decision, it was ensured that students have not taken reinforcement workshops or another course that involves the development of logical reasoning processes in use outside the curricular teaching process. All participants were assigned through the enveloping volunteer system, so each of the parents signed the informed consent to include each child in this sample.

2.1 Instrument and procedure

We use the Pre-calculation Test (PC) [28]. It is a test used in the Latin American context, prepared for students from four to seven years of age. The instrument aims to measure the development of mathematical reasoning in children with an age range of four to seven years old. This test includes the measurement construct on mathematical reasoning processes in the dimensions: (1) Ordinal numbers, (2) cardinality; (3) conservation. Analysis processes were executed for content validation ($n_{(agreements)}$ = 98.5%) and test-subtest correlation reliability (r = 7.81; p <.001). For the procedure, we resorted to establishing multidynamic effects according to the evidence in other investigations [21], [22]: (a) timing of game execution; (b) utility of prior knowledge. The development of the experimental program was carried out during six months of work, among which 95 gamified sessions were applied with parallel accompaniment of the Plants & Zombies video game. These were applied before and after each mathematical activity that included steps to apply logical reasoning.

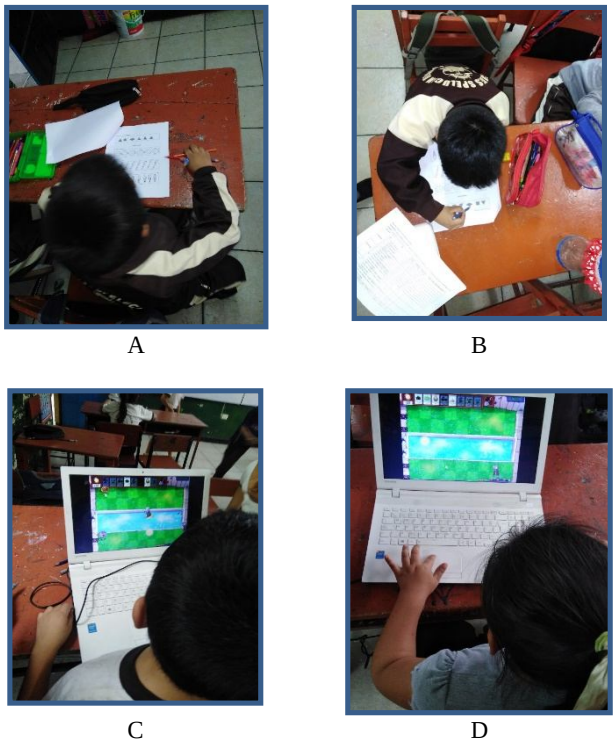

Figure 2: Interaction models in the Plants & Zombies video game in learning logical reasoning.
Note: A (Troubleshooting); B (Development of ordinal operations); C (Cooperative work in Gamification); D (exemplification of the companion's work).

Figure 2 shows how the evaluation activities were developed in mathematical activities, as well as the reasoning evaluation (A and B). On the other hand, the way in which the students solved the problems before and after the application of the video game (C and D) is demonstrated. The organization of the students with respect to the objectives of the experimental

program, determined the way in which each student positioned themselves for the use of the video game. Most of the activities were developed through cooperative (group) participation to promote collaborative skills in all members of the sample.

3. RESULTS

In the experimental group there were descriptive differences regarding logical reasoning. Figure 3 shows the increase in effectiveness in the logical reasoning tasks that they developed from the PC test, with a difference of approximately 10%. Regarding the inferential comparison, the data report presented differences (sr = 2431.01; p <.001). Logical reasoning increased in the group of students after six months of gamified exercise in their participation in the experimental group.

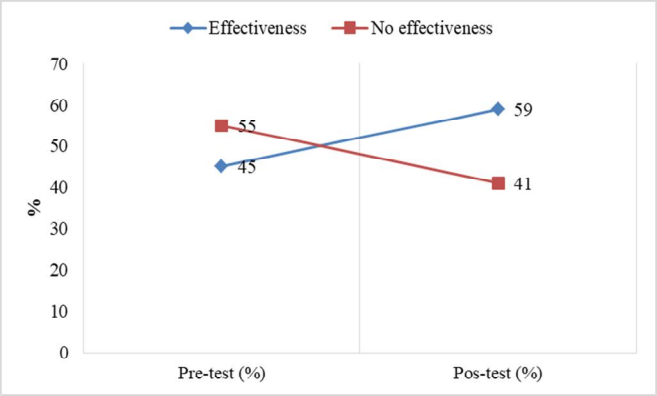

Figure 3: Results in logical reasoning.
Source: Research database.

In the ordinality dimension we also found differences, but with little tendency in the statistical comparison between the pretest and pos-test measurements (sr = 21301.50; p <.005), although in the descriptive analysis these differences also highlighted this advance (*pre-test* = 35 %; *pos-test* = 78%). These findings reveal the effects found in the ordinality principle, the students learned to recognize positions between elements with categorical or hierarchical order; they organized sequences according to some sequential mathematical pattern. These evidences are comparable to others that show similar results in the mathematical construction of concepts and numbers [13], [14]. Some observational evidence revealed that the participants mastered levels 1 and 2 (of less difficulty), which could have these effects in this dimension. The increase in the approach to levels of greater complexity in videogames is based on other studies that have shown that its cognitive mechanism increases some important mathematical components in the reasoning itself [2], [13], [23].

Regarding the cardinality dimension, we found significant differences of high value in the statistical comparison (Sr = 3022.00; p <.001). Although these results are important, it is important to note that students may have achieved the development of this dimension through the effects of level 3, in whose processing the students had to obtain more opportunities to avoid losing medals or scores they had in the game. The possibility of losing the character's life required him to be able to activate the object location processes along with the corresponding numerical calculation. This evidence allows us to declare that active mathematical models (those that include a lot of related information) need fluency processes, as well as requiring students to prioritize their rewards through the use of quick strategies, but that are also logical [19], [20]. Given this, it can be accepted that prior knowledge is important [21], [22], which in this case has occurred when students tried to avoid obstacles that had already preceded overcoming level 1 or 2.

Finally, in the conservation dimension, notable significant differences were found (sr = 4250.01; $sig.$ = .000; p <.001), which indicated that the students represented the quantities in a concrete way; they recovered their meaning when using the operative memory to calculate quantities; and retrieve the numerical representation. This is because the game Plants & Zombies allowed in its level 3, it provided opportunities to confront the enemy again, so that the participants again faced complex situations to overcome them, representing them as negative objectives for the continuity of their success, to achieve more scores, and discover other more complex later episodes.

This showed us that mathematical processes involve the use of operability through unconsciousness for calculation in situations that may be motivational, in turn; exacerbate the sense of victory in the players. These findings allow mentioning that reasoning can be provoked with games that imply achieving new objectives [1], [6]. Evidence reveals that Gamification as a companion process allows the development of gamified learning based on empathy and interpersonally [19], [21], [22], [24]. All this is important if the students are predisposed to continue playing and solving problems as happened in the experimentation group.

5. CONCLUSION

The Plants & Zombies game is an important playful experience, through which we manage to develop scores in the numerical calculation as a representative dimension of cognitive seriation. Likewise, the cardinality and conservation functions were increased. The development of conservation through this experience was much more crucial, due to the strong cognitive value that the game developed

through the evolution of levels 2 and 3, and its complexity revealed in the search for new gains, scores and sustainability of the life of the game.

The effects based on obtaining scores, overcoming obstacles and immediate calculation of scores allowed the study subjects to develop the capacity for orientation, time distribution and prevention; as well as greater fluency and decision in basic operations. This occurred by constantly evaluating the risks that each level of complexity of the video game required of them. Video games, conceived as part of the set of didactic elements for education, should be included in the school curriculum of schools that include students with problems in accessing reliable reasoning in the area of basic mathematics.

REFERENCES

1. Bragg, L.A. & Herbert, S. **A "True" Story about Mathematical Reasoning Made Easy**, *Australian Primary Mathematics Classroom*, Vol. 4, pp. 3-6, 2017. https://eric.ed.gov/?q=+logical+reasoning+for+children&id=EJ1163819
2. Çelik, M. **Examination of Children Decision Making Using Clues during the Logical Reasoning Process**, *Educational Research and Reviews*, Vol. 12, no 16, pp. 783-788, 2017. https://doi.org/10.5897/ERR2017.3297
3. Gee, J.P. **What video games teach us about learning and literacy**, Madrid: Aljibe, 2004.
4. Matallouni, A., Hanner; N., & Zarnekow, R. **Introduction to Gamification: Foundation and Underlying Theories**, in *Gamification. Using Game Elements in Serious Contexts*, S. Stieglitz; C. Lattemann; S. Robra-Bissantz; R. Zarnekow & T. Brockamnn, Switzerland: Springer, 2018, ch. 2, pp. 3-18.
5. Teixes, F. **Gamification: fundamentals and applications**, Catalunya: UOC, 2014.
6. Wong, T. T.-Y. **Is Conditional Reasoning Related to Mathematical Problem Solving?**, *Developmental Science*, Vol. 21, no 5, pp. e12644, 2018. http://dx.doi.org/10.1111/desc.12644
7. Goranko, V. **Logic as a Tool. A Guide to Formal Logical Reasoning**, UK: Wiley, 2016.
8. Morris, B.J. & Shunn, C.D. **Rethinking logical reasoning skills a strategy perspective**, in *Methods of thought*, M. Roberts & E. Newton, New York: Taylor & Francis Group, 2016, pp. 31-55.
9. Yao, Y.; Xu, J.; Shi, J. & Xu, B. **Learning to activate logic rules for textual reasoning**, *Neural Networks*, Vol. 106, pp. 42-49, 2018. https://doi.org/10.1016/j.neunet.2018.06.012
10. Gilhooly, K.L. **Working memory and strategies in reasoning**, in *Methods of thought*, M. Roberts & E. Newton, New York: Taylor & Francis Group, 2016, pp. 57-75.
11. Hervás, C.; Ballesteros, C. y Corujo, M. del C. **Robotics and curriculum: experimenting with new methodological and didactic strategies for their curricular integration**, in *Hispano-Ecuadorian investigative and innovative experiences.*, M. Compte; E. López; M. Morales y A. Martín, Sevilla: AFOE, 2018, pp. 73-93.
12. Armier, D. D., Jr.; Shepherd, C. E.; Skrabut, St. **Using Game Elements to Increase Student Engagement in Course Assignments**, *College Teaching*, Vol. 64, no 2, pp. 64-72, 2016. http://dx.doi.org/10.1080/87567555.2015.1094439
13. Martyniuk, S. V. **Game On!--Teaching Video Game Studies in the Arts Classroom**, *Art Education*, Vol. 71, no 3, pp. 14-19, 2018. http://dx.doi.org/10.1080/00043125.2018.1436325
14. Sergeeva, M.G.; Ogurechnikova, N.L.; Zarembo, G.V.; Nikashina, N.V.; Nagornova, E.V.; Vasilenko, S.A.; & Baranova, E.A. **Methodology Development of the University Teacher´s Creative Abilities with the Help of Information Technologies**. *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no 6, pp. 2800-2805, 2019. https://doi.org/10.30534/ijatcse/2019/19862019
15. Hung, A.C.Y. **A Critique and Defense of Gamification**, *Journal of Interactive Online Learning*, Vol. 15, no 1, pp. 57-72, 2017. http://www.ncolr.org/jiol/issues/pdf/15.1.4.pdf
16. Marín, I. **We play? How playful learning can transform education**, España: Paidós, 2018.
17. Glaser-Opitz, H. & Budajová, K. **THE MATH – open source application for easier**, *Acta didactica Napocensia*, Vol. 9, no 1, pp. 45-50, 2016. https://eric.ed.gov/?id=EJ1103424
18. Sudarmilah, E.; Ayub, I.H.; Puspa, D.A.; Dinar, W.; & Yuliana, I. **Game Education of Disaster Mitigation: A Systematic Literature Review**. *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no 6, pp. 2940-2943, 2019. https://doi.org/10.30534/ijatcse/2019/42862019
19. Dos Santos Barbosa, G. & Gomes Araujo, C. **As contribuições do jogo rouba monte no desenvolvimento de estratégias de contagem por crianças do terceiroano do ciclo de alfabetização**, *Revista de Educação, Ciências e Matemática*, Vol. 6, no 2, pp. 42-60, 2016. http://publicacoes.unigranrio.edu.br/index.php/recm/article/view/4029
20. Fanari, R.; Meloni C. & Massidda, D., **Early numerical competence and number line task performance in kindergarteners**, in *Proc. 14th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2017)*, Vilamoura, Portugal, 2017, pp. 70-76. https://eric.ed.gov/?q=Learning+the+numerical+count+in+children+&pg=6&id=ED579448

21. Al Irsyadi, F.Y.; Supriyadi, Kurniawan, Y.I. **Interactive Educational Animal Identification Game for Primary Schoolchildren with Intellectual Disability**. *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no 6, pp. 3058-3064, 2019. https://doi.org/10.30534/ijatcse/2019/64862019
22. Higgins, K.; Crawford, L.; Huscroft, J. & Horney, M. **Investigating Student Use of Electronic Support Tools and Mathematical Reasoning**, *Contemporary Educational Technology*, Vol. 7, no 1, pp. 1-24, 2016. http://www.cedtech.net/past2.asp?numara=71
23. Ouariachi, T.; Olvera, M y Gutiérrez, J. **Analysis of online change games: exploring opportunities**, *Revista Electrónica de Investigación Educativa*, Vol. 19, no 3, pp. 104-114, 2017. https://doi.org/10.24320/redie.2017.19.3.1298
24. Ayal, C.; Kusuma, Y.; Sabandar, J. & Afgan, J. **The Enhancement of Mathematical Reasoning Ability of Junior High School Students by Applying Mind Mapping Strategy**, *Journal of Education and Practice*, Vol. 7, no 25, pp. 50-58, 2016. https://iiste.org/Journals/index.php/JEP
25. Lubis, A. & Nasution, A.A. **How Do Higher-Education Students Use Their Initial Understanding to Deal with Contextual Logic-Based Problems in Discrete Mathematics?** *International Education Studies*, Vol. 10, no 5, pp. 72-86, 2017. https://doi.org/10.5539/ies.v10n5p72
26. Bozkurt, A. & Durak, G. **A Systematic Review of Gamification Research: In Pursuit of Homo Ludens**, *International Journal of Game-Based Learning*, Vol. 8, no 3, pp. 15-33, 2018. http://dx.doi.org/10.4018/IJGBL.2018070102
27. Zhang, B.; Robb, N.; Eyerman, J. & Goodman, L. **Virtual Worlds and Gamification to Increase Integration of International Students in Higher Education: An Inclusive Design Approach**, *Journal of Distance Education*, Vol. 32, no 2, pp. 1-21, 2017. http://www.ijede.ca/index.php/jde/issue/view/78
28. Milicic, N. & Schmidt, S. ***Precalculus Test***. Santiago de Chile: Universitaria S.A., 2002.