International Journal of Evaluation and Research in Education (IJERE)
Vol. 13, No. 3, June 2024, pp. 1917~1930
ISSN: 2252-8822, DOI: 10.11591/ijere.v13i3.26432

Educational video games to improve the learning process

Alejandro Cachay-Gutierrez, Michael Cabanillas-Carbonell
Faculty of Engineering, Universidad Privada del Norte, Lima, Peru

Article Info

Article history:

Received Dec 29, 2022
Revised Dec 13, 2023
Accepted Dec 23, 2023

Keywords:

Acquired knowledge
Learning process
Motivation
Obtained qualification
Video game

ABSTRACT

The pandemic has made us quickly migrate to virtual environments, for this reason, we must look for quality education mechanisms, thus continuing with the same level of traditional teaching. This research aims to determine the influence of an educational video game in improving the learning process, for which a study was carried out on first-cycle university students. The level of the research is explanatory, of the applied type, with a quantitative approach and quasi-experimental design. We worked with two groups already formed in which 65 students participated. The following results were obtained: an increase in the grade of motivation of 12.9%, an improvement in the acquired knowledge indicator of 46.34%, and an improvement in the obtained qualification indicator of 12.77%. Therefore, it is concluded that an educational video game influences the motivation, acquisition, and application of learning.

Corresponding Author:

Michael Cabanillas-Carbonell
Faculty of Engineering, Universidad Privada del Norte
Av. Tingo Maria Nro. 1122 Lima Cercado, Perú
Email: mcabanillas@ieee.org

1. INTRODUCTION

The COVID-19 pandemic forced countries around the world to suspend face-to-face teaching, and moved to online classes, putting at risk the achievement of education expectations concerning the proposed objectives [1]. For this reason, Information and communications technology (ICT) have a crucial role in education from a sustainable perspective, which is why most countries have integrated them into educational settings [2], [3]. In particular, these technologies can be expected to become increasingly relevant, as the COVID-19 outbreak has forced the world to reimagine a 'new normal' that requires fewer face-to-face human interactions, especially in work settings, and increased use of different technologies to compensate for lost interactions [4].

The incorporation of virtuality as a support tool for attendance is perceived by students as a didactic, dynamic, modern, participatory, and innovative tool that allows interaction between teachers and participants [5]. These new methodologies allow the student to develop critical thinking, improve both written and oral communication, and above all, the development of skills, thus achieving a comprehensive increase in knowledge [6]. The application of technologies for learning is now considered a crucial part of teaching-learning in higher education and vital evidence of innovative teaching practices used to improve the teaching-learning process [7], [8]. University professors have proven to be the main drivers of change; their involvement and motivation have been very important in this process, therefore, digital teaching competence has been very important in this teaching-learning process [9]. In Polito and Temperini [10], it is shown that gamification is recognized as a very significant and adequate methodology to promote the motivation and commitment of students. In addition, several researchers [11], [12] mentioned the approach to gamification, both in experiential learning and in the research-based learning experience, as an improvement of skills such as self-efficacy, goal setting, and cooperation. Krishnan *et al*. [13] affirm that this type of learning encourages the active participation

of students in class and interest in a course. Carbonell *et al*. [14] mention that gamification is applied by developing activities to achieve learning objectives in a fun and competitive environment, thus increasing their motivation. This is reinforced by Gamboa-Ramos *et al*. [15] where the active learning of the university student is promoted using technological resources that improve the teaching-learning process by incorporating playful interactive interfaces. The learning based on digital games allows awakening active learning where the student builds his knowledge, allowing students to be the active agents of their learning in a meaningful way by being the protagonists of their learning [16]. According to Chans and Castro [17], gamification seeks to involve players and motivate them to participate, improving problems such as lack of motivation in learning and affirming that student learning increases when they are more committed and interested. For this reason, how knowledge is imparted has had to be redesigned, considering the needs, preferences, and orientations of the new digital natives to be successful in the current technological context in which we find ourselves [18].

Gamification is adapted to the needs of distance learning, resulting in positive comments from most of the students who highlighted learning in a new, more entertaining way, promoting teamwork, commitment, constant interest, and motivation [19], [20]. Motivation for learning is the key to improving the learning process, for this reason, the main objective is to involve students so they are impulse to do things because they feel better doing them [21]. The opportunities offered by game-based learning are multiple, in addition, gamification is a means to improve the learning, motivation, and attitude of students both at the primary level and in higher education [22].

The success of gamification strategies requires adequate resources that support all the activities of the gamification process, from identifying business objectives to monitoring gamification strategies [23]. There is a growing interest in using gamification in the educational field as a means to improve student participation, however, these technological innovations present a lack of adoption by university educational centers, resulting in many university students not having experience interacting with innovative technological equipment [24].

2. RESEARCH METHOD

In order to determine the influence of an educational video game in improving the learning process of university students, 65 students belonging to the first cycle of the School of Fine Arts of Trujillo participated in this research, which is located in Peru, Department of La Libertad, city of Trujillo. During the year 2022, the student data was collected remotely, making it necessary to coordinate with a teacher in charge of the virtual entry to their class session. Regarding selecting the methodology for solution development, Table 1 shows a list of five agile methodologies that are mostly used for systems development [25]. From the six criteria, a score from a scale from one to five has been considered, where one represents the lowest score and five represents the highest score.

Table 1. Results of the criteria for the selection of the agile methodology

Agile methodologies	FDD	TDD	DSDM	XP	Scrum
Greater presence on the internet	3	3	2	4	5
Better documentation	3	3	3	5	4
Certified and trained	2	4	2	3	5
Communities	3	2	3	3	4
Business presence	2	2	3	4	5
Software projects	3	3	2	4	5
Total	16	17	15	23	28

After having chosen the methodology for the development of the project, the scrum framework is chosen considering the results obtained from the table for the selection of the agile methodology. Scrum proposes to carry out the work in short cycles that can be from one week to one month, this period is called sprint. The team members have short meetings where they decide which features of the product backlog (list of requirements for software development) will be part of each cycle, they also decide who will work on each cycle and the duration of the tasks. The benefit of working in these cycles is that at the end of each of them, a product is ready so that if there are problems, the work team reverts to a previous work milestone without having to start all over again [26]. In this sense, scrum helps companies that have difficulties following a waterfall methodology or if they do not use a methodology and is a reference framework within the agile development methodology that implements these guidelines to directly help project management of complex software and deliver it more simply [27].

The main feature of the project is the connection of the educational video game with the PlayFab service to manage the data obtained from the students during the interaction with the educational video game,

as shown in Figure 1. The video game has been developed in Unity, which is a complete platform for game development that allows it to be deployed on the main operating systems, speeding up the process of developing and optimizing the game. The objective is to improve student learning and reinforce the retention of what has been learned based on memory dynamics of images and text of the same game.

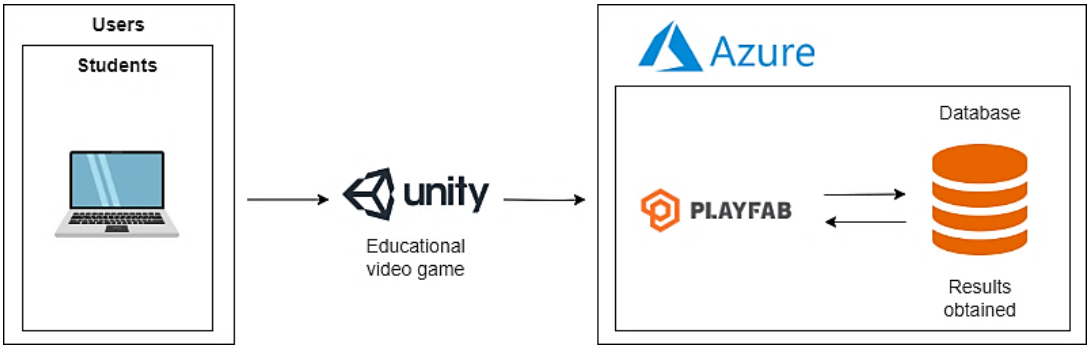

Figure 1. Software architecture diagram

2.1. Planning and specification

In this phase, all the requirements for the elaboration of the user stories and their expected result are considered. In study by Zayat and Senvar [27], it is mentioned that user stories are used within agile methodologies to specify user requirements in common and understandable language. Table 2 describes the user stories that are implemented for the development of the project.

Table 2. User stories

User story	Role	Functionality	Result
US01	Administrator	I want it to be entered with the institutional email and a password.	Validate the information of the students who enter the educational video game.
US02		I want the questions answered correctly to be posted on an online scorecard.	Check the number of questions answered correctly when interacting with the educational video game.
US03		I want questions answered wrongly to be posted on an online scorecard.	Check the number of questions answered incorrectly when interacting with the educational video game.
US04		I want the points obtained to be published in an online leaderboard.	Check the number of points obtained by interacting with the educational video game.
US05	Student	I want to be able to see pictorial works by stages of art.	Interact with the images of the pictorial works through a video game.
US06		I want to collect information about pictorial works through levels of an educational video game.	Acquire more information about pictorial works.
US07		I want the information-gathering levels to have gameplay, difficulty, sound, and animations.	Motivate the use of the educational video game when collecting the information.
US08		I want to answer the questions about the information collected through a level from the educational video game.	Verify the information learned about pictorial works.
US09		I want the learning verification level to have gameplay, difficulty, sound, and animations.	Motivate the use of the educational video game by verifying the information learned.

After having the user stories, each of the functionalities must be prioritized using the product backlog. Zayat and Senvar [27] mentioned that a product backlog is a tool that consists of preparing a list of all those tasks that we want to carry out during the development of a project, establishing the priority of each of them, and the effort it will require during the development phase. Table 3 shows the prioritized product backlog. For the planning of the delivery of each sprint, the development time of each user story and the corresponding revisions of the deliverable has been considered, in addition, the functional tests for each user story are considered in the planning stage. The schedule for the planning of the sprints is found in Table 4.

Table 3. Product backlog

Sprint	Code	User stories	Effort (score: 2,4,6,8,10)	Priority
1	US05	As a student, I want to be able to see pictorial works by stages of art to be able to interact with the images of pictorial works through an educational video game.	4	Medium
2	US06	As a student, I want to collect information about pictorial works through levels of an educational video game to acquire more information about pictorial works.	6	Medium
	US07	As a student I want the information collection levels to have playability, difficulty, sound, and animations to motivate the use of the educational video game when collecting information.	8	High
3	US08	As a student, I want to answer the questions of the information collected through a level from the educational video game to verify what I have learned about pictorial works.	6	Medium
	US09	As a student, I want the level of verification of the information learned to have playability, difficulty, sound, and animations to motivate the use of the educational video game when verifying what has been learned.	8	High
4	US01	As an administrator, I want to enter the institutional email and a password to validate the information of the students who enter the educational video game.	8	High
5	US02	As an administrator, I want the questions answered correctly to be published in an online score table to verify the number of questions answered correctly when interacting with the educational video game.	6	Medium
	US03	As an administrator, I want incorrectly answered questions to be posted to an online scorecard to check the number of wrongly answered questions when interacting with the educational video game.	6	Medium
	US04	As an administrator, I want the points obtained to be published in an online score table to motivate the use of the educational video game by verifying what has been learned.	8	Medium

Table 4. Sprint planning

Sprint number	Start date	Delivery date
1	10/01/2022	21/01/2022
2	24/01/2022	25/02/2022
3	28/02/2022	01/04/2022
4	04/04/2022	08/04/2022
5	11/04/2022	15/04/2022

2.2. Sprint development

2.2.1. Sprint 1

For sprint 1, the development of the first scenario of the video game where the student will be able to visualize and interact with the images of pictorial works is considered. The tasks corresponding to the sprint were completed and the necessary tests were carried out to verify their correct operation. Figure 2 shows the capture of the development of sprint 1.

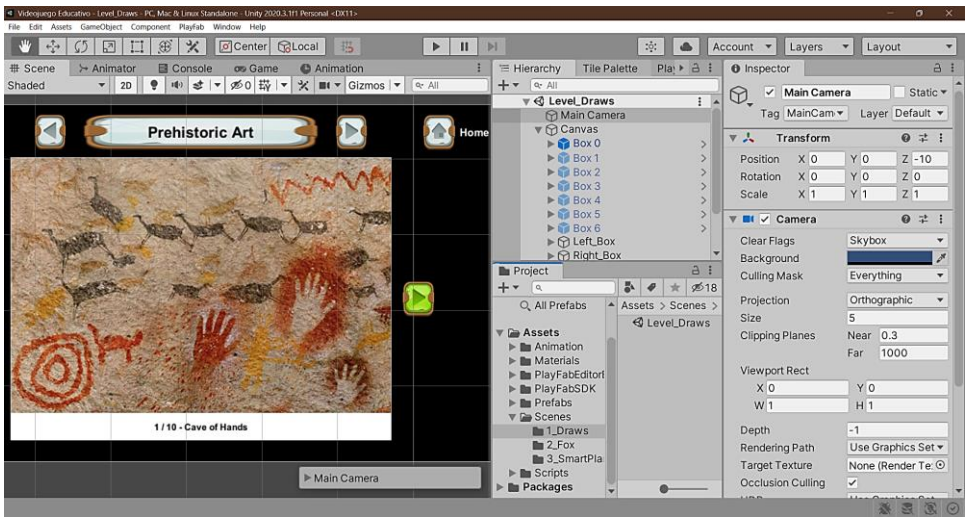

Figure 2. Selection of pictorial samples

2.2.2. Sprint 2

For sprint 2, the development of the second scenario of the video game where the student will be able to collect information about pictorial works is considered. The tasks corresponding to the sprint were completed and the necessary tests were carried out to verify their correct operation. Figure 3 shows the capture of the development of sprint 2.

Figure 3. Creation of levels of the second scenario

2.2.3. Sprint 3

For sprint 3, the development of the third scenario of the video game where the student will be able to verify the information learned about pictorial works is considered. The tasks corresponding to the sprint were completed and the necessary tests were carried out to verify their correct operation. Figure 4 shows the capture of the development of sprint 3.

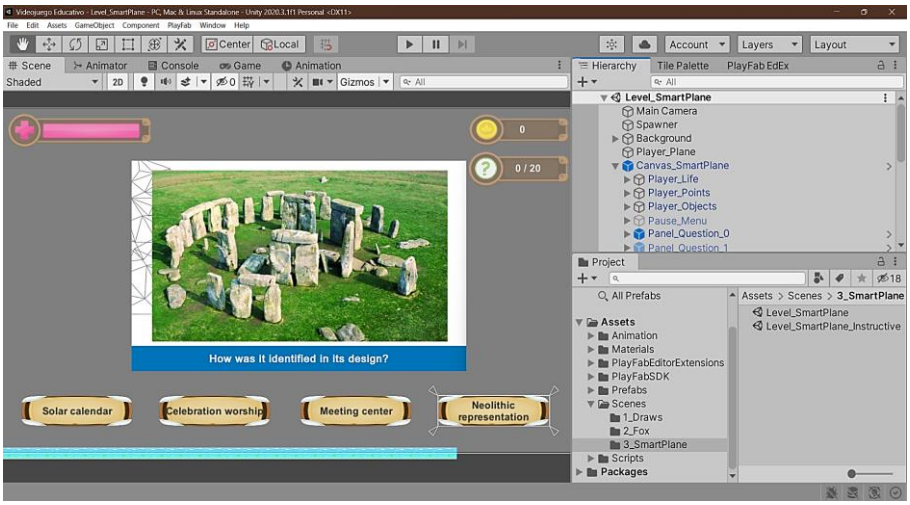

Figure 4. Implementation of questions with options

2.2.4. Sprint 4

For sprint 4, the development of the login interface is considered where the student is able to validate their data to enter the video game. The tasks corresponding to the sprint were completed and the necessary tests were carried out to verify their correct operation. Figure 5 shows the capture of the development of sprint 4.

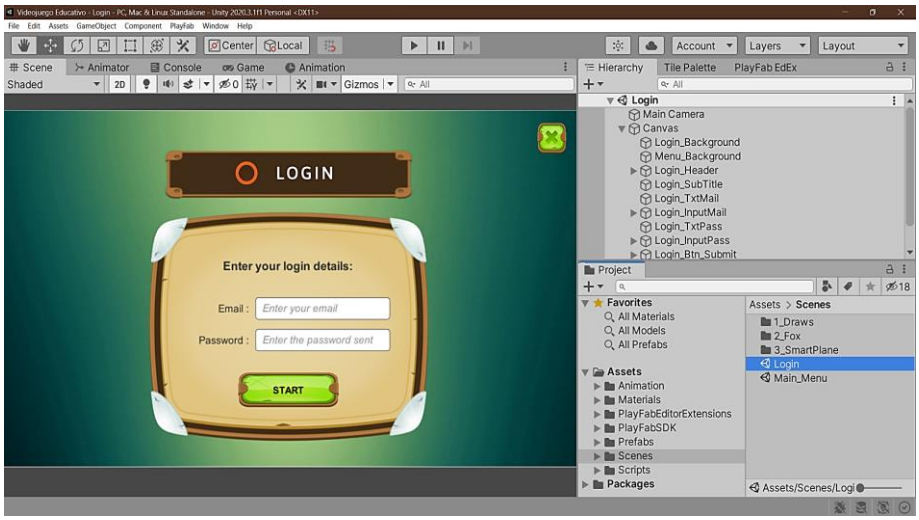

Figure 5. Creation of login scenario

2.2.5. Sprint 5

The development of the results interface obtained at the end of the game and its publication in an online results table is considered for sprint 5. The results obtained from the third scenario will be published concerning the questions answered correctly, questions answered wrongly, and the number of points obtained. Figure 6 shows the capture of the development of sprint 5. Figure 7 shows a screenshot of the user registration in PlayFab, with which they can perform their respective login in the educational video game. Figure 8 shows a screenshot of a part of the code programmed for the main character of the educational video game, which was made through the Visual Studio Code program.

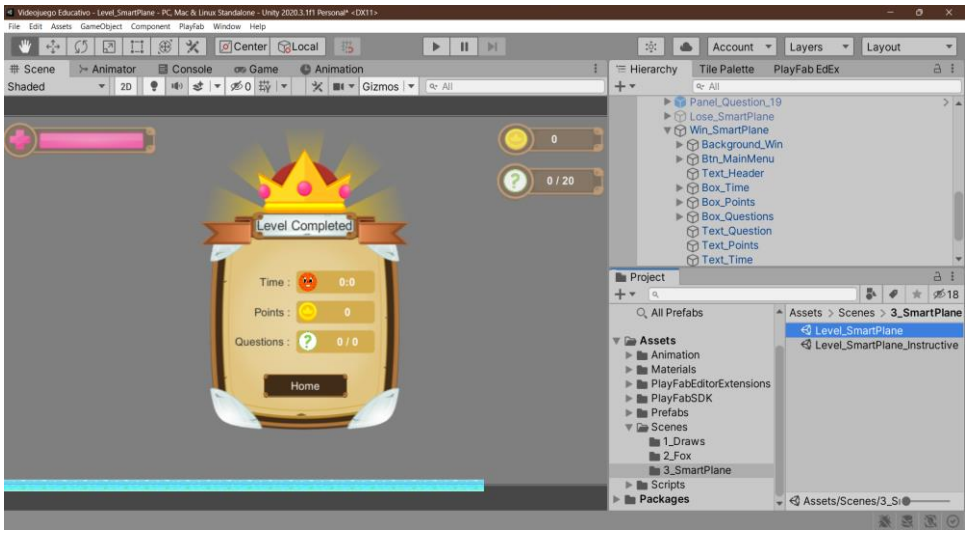

Figure 6. Creation of results interface

2.3. Software operational test

In this stage, the results obtained from the project were analyzed, covering what went well and what can be improved for future actions. New ideas or methods are also provided to improve and promote good practices in the development of a project. In this investigation, the type of quasi-experimental design was applied with a pre-test and a post-test on a sample divided into two groups already formed, where one group represents the experimental and the other control group.

$$Eg = O1\ X\ O2$$
$$Cg = O3 - O4$$

Where:
Eg=Experimental group (45 students)
Cg=Control group (20 students)
X=Stimulus (educational video game)
O1, O2, O3, O4=Measurements

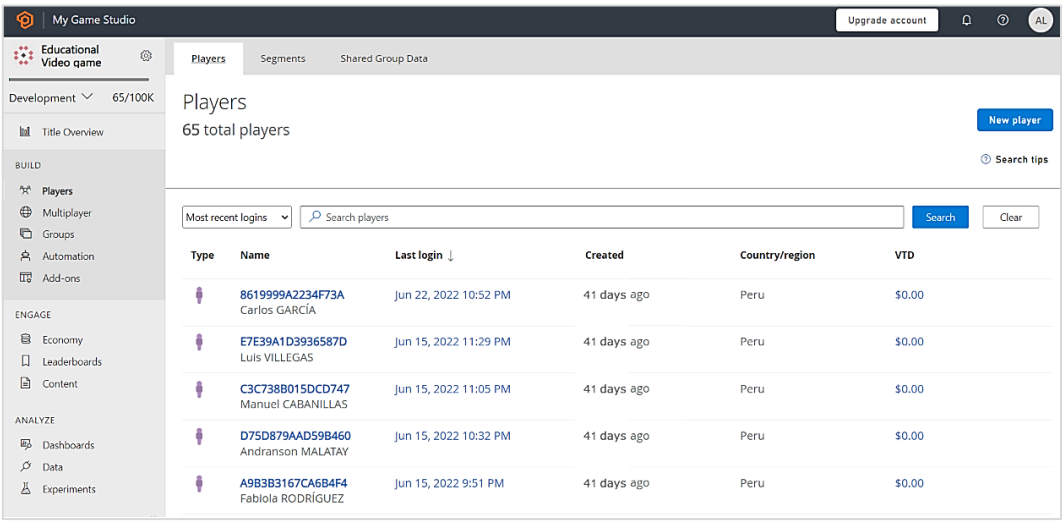

Figure 7. Creation of the list of users

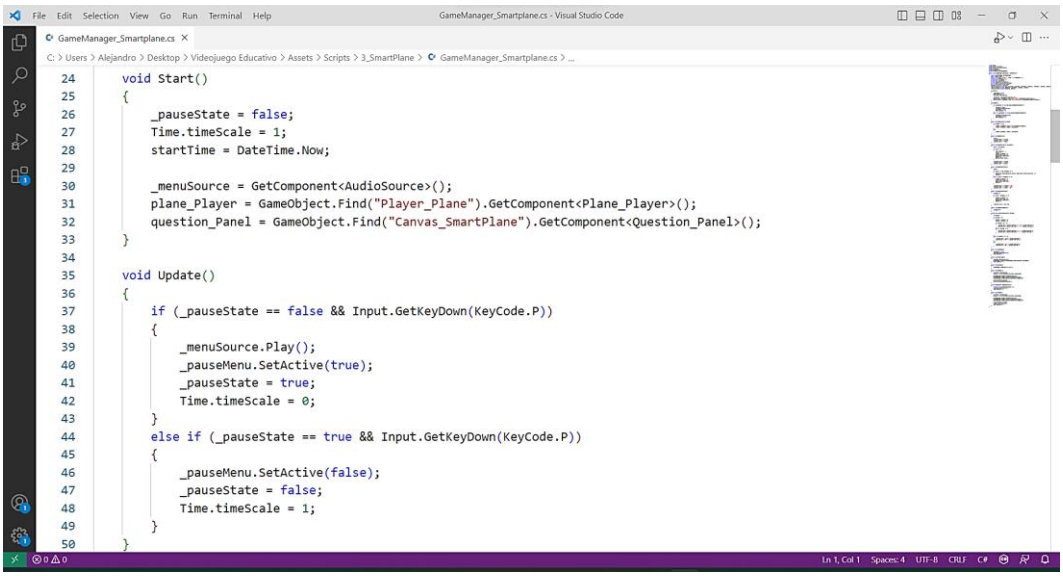

Figure 8. Extract from the source code

3. RESULTS AND DISCUSSION

After having carried out the pre-test and post-test in the experimental group, Table 5 shows the results obtained for the research indicators, where KPI1 is measured from 1 to 5, KPI2 from 0 to 20 and KPI3 from 0 to 20. Table 6 shows the results of the mean obtained for each KPI, and the results from Table 5.

Table 5. Pre-test and post-test results

Student number	KPI1		KPI2		KPI3	
	Pre	Post	Pre	Post	Pre	Post
1	2.9	3.3	10	10	15	17
2	1.1	4.0	7	8	16	17
3	2.0	3.6	10	10	17	16
4	2.9	5.0	12	12	16	18
5	3.6	4.4	12	12	5	16
6	4.2	3.9	13	11	18	17
7	4.3	3.9	6	12	16	17
8	3.0	3.9	9	13	17	17
9	3.6	4.7	9	12	5	18
10	4.0	3.2	9	14	18	18
11	3.4	4.4	11	14	15	17
12	4.1	4.1	11	14	17	5
13	2.5	3.4	5	10	16	17
14	3.2	3.8	10	13	17	19
15	3.4	4.2	10	14	16	17
16	4.3	4.7	13	15	17	18
17	3.7	4.3	13	13	16	5
18	3.6	4.5	13	13	16	18
19	3.5	3.8	8	11	5	18
20	3.6	4.4	10	9	17	5
21	1.4	4.8	9	8	5	18
22	4.5	5.0	14	11	17	18
23	3.8	4.3	12	8	5	16
24	3.4	1.8	10	10	17	19
25	3.2	4.9	13	18	17	18
26	4.0	4.9	11	18	18	17
27	3.8	4.5	6	19	16	18
28	3.9	4.5	11	20	18	18
29	4.9	4.0	10	19	16	18
30	4.1	5.0	12	17	16	17
31	4.7	4.5	9	20	18	17
32	4.2	3.5	9	13	14	18
33	4.8	3.3	10	18	16	17
34	4.7	3.1	7	20	15	18
35	4.4	4.3	14	8	16	18
36	3.5	4.9	6	20	16	17
37	4.6	4.9	11	20	8	17
38	4.7	4.5	6	17	14	17
39	3.7	4.5	11	13	17	18
40	4.4	4.0	6	19	17	17
41	4.3	5.0	10	19	17	18
42	4.0	4.5	8	19	8	18
43	3.4	3.3	9	18	16	17
44	4.2	3.8	12	16	8	8
45	2.6	4.2	6	20	15	17

Table 6. Results of the pre-test and post-test of the research indicators

Indicator	Group	Pre-test	Post-test
KPI1: Grade of motivation	Control	3.570	3.700
	Experimental	3.691	4.167
KPI2: Acquired knowledge	Control	9.65	10.95
	Experimental	9.84	14.40
KPI3: Obtained qualification	Control	14.25	15.25
	Experimental	14.56	16.42

3.1. KPI1 results

From the results obtained from Table 7, it is indicated that in the pre-test the value of 3.691 was obtained in the mean and for the post-test the value of the mean was 4.167. The bar chart with the mean value of the pre-test and post-test is shown in Figure 9, showing an improvement of 12.9% for the first indicator. In more detail, it is shown in Figure 10 an increase of 15.11% concerning the students who marked the option "Totally agree", in the case of the students who marked "Agree" increased from 3.11%, students who marked the "Neutral" option decreased by 8.22%, students who marked the "Disagree" option decreased by 5.78%, and students who marked the "Totally disagree" option decreased by 4.23%. Table 8 shows that, after performing the McNemar test for qualitative variables, the significance value is 0.031, thus confirming that an educational video game significantly influences learning motivation.

Table 7. Descriptive statistics of KPI1

		Statistics	
		Grade of motivation-pre	Grade of motivation-post
N	Valid	45	45
	Missing	0	0
Mean		3.691	4.167
Median		3.800	4.300
Mode		3.4[a]	4.5
Std. Deviation		.8380	.6551
Variance		.702	.429
Minimum		1.1	1.8
Maximum		4.9	5.0
Sum		166.1	187.5
Percentiles	25	3.400	3.800
	50	3.800	4.300
	75	4.300	4.600

a. Multiple modes exist. The smallest value is shown.

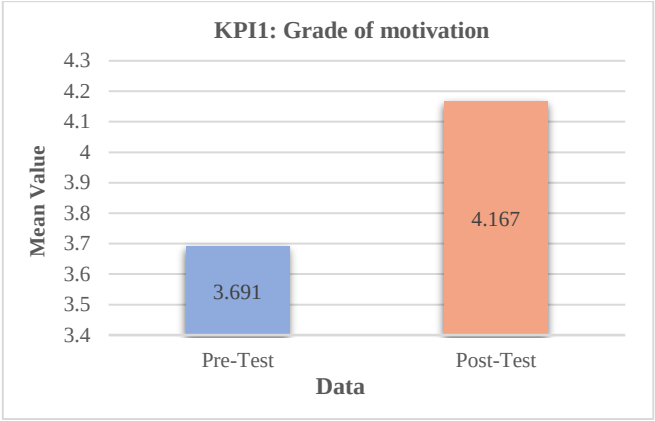

Figure 9. Pre- and post-testing of KPI1 measured on a Likert scale

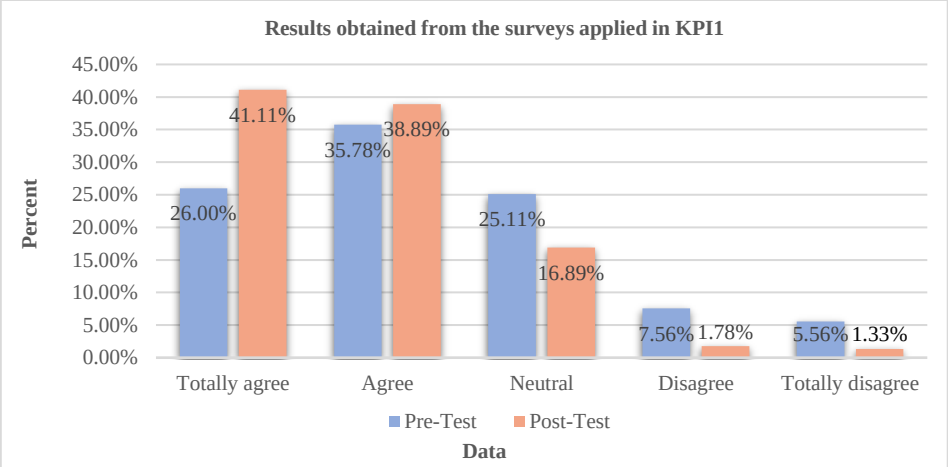

Figure 10. Graph of the results obtained from the surveys applied in KPI1

Table 8. McNemar test of KPI1

Test statistics[a]	
	Grade of motivation - Pre Grade of motivation - Post
N	45
Exact Sig. (2-tailed)	.031[b]

a. McNemar Test
b. Binomial distribution used.

3.2. KPI2 results

From the results obtained from Table 9, it is indicated that in the pre-test the value of 9.84 was obtained in the mean and for the post-test the value of the mean was 14.40. The bar chart with the mean value of the pre-test and post-test is shown in Figure 11, showing an improvement of 46.34% for the second indicator. Figure 12 shows that the significance value in the pre-test is 0.044 and in the post-test the significance value is less than 0.005. Therefore, it is considered a non-normal distribution. Table 10 shows that, after having carried out the non-parametric Wilcoxon test, the value of significance is less than 0.001, this value is less than the limit to accept the research hypothesis, thus being able to affirm that an educational video game significantly influences learning acquisition.

Table 9. Descriptive statistics of KPI2

		Statistics	
		Acquired knowledge-pre	Acquired knowledge-post
N	Valid	45	45
	Missing	0	0
Mean		9.84	14.40
Median		10.00	14.00
Mode		10	13a
Std. Deviation		2.412	3.997
Variance		5.816	15.973
Minimum		5	8
Maximum		14	20
Sum		443	648
Percentiles	25	8.50	11.00
	50	10.00	14.00
	75	12.00	18.50

a. Multiple modes exist. The smallest value is shown.

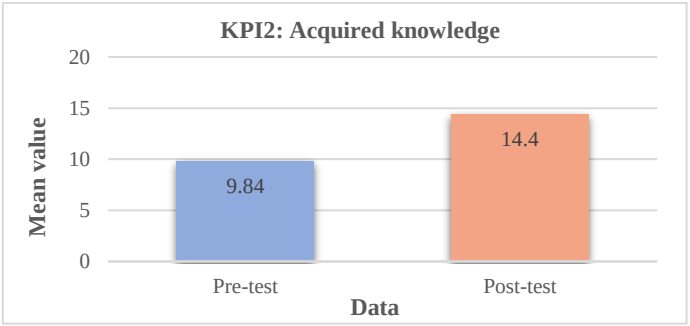

Figure 11. KPI2 pre- and post-test graph, quantified as a score from 0 to 20

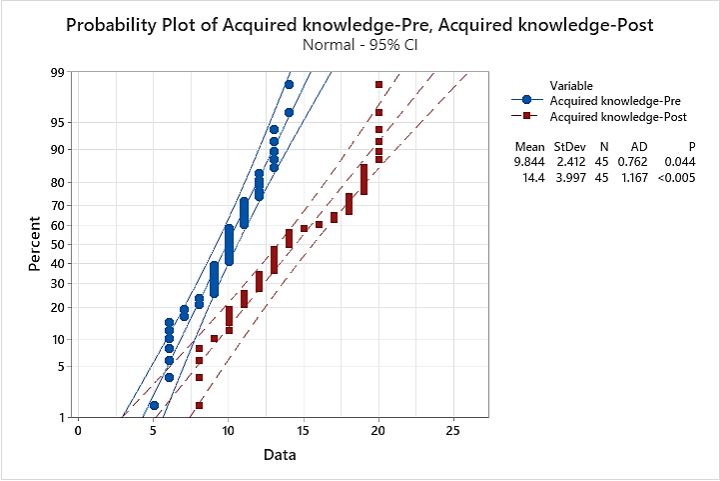

Figure 12. KPI2 normality test plot

Table 10. Wilcoxon test of KPI2

Test statistics[a]	
	Acquired knowledge-pre & Acquired knowledge-post
Z	-4.567[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon signed ranks test
b. Based on negative ranks.

3.3. KPI3 results

From the results obtained from Table 11, it is indicated that in the pre-test the value of 14.56 was obtained in the mean and for the post-test the value of the mean was 16.42. The bar graph with the average value of the pre-test and post-test is shown in Figure 13, observing an improvement of 12.77% for the third indicator.

Table 11. Descriptive statistics of KPI3

		Statistics	
		Obtained qualification-pre	Obtained qualification-post
N	Valid	45	45
	Missing	0	0
Mean		14.56	16.42
Median		16.00	17.00
Mode		16	17a
Std. Deviation		4.121	3.461
Variance		16.980	11.977
Minimum		5	5
Maximum		18	19
Sum		655	739
Percentiles	25	15.00	17.00
	50	16.00	17.00
	75	17.00	18.00

a. Multiple modes exist. The smallest value is shown.

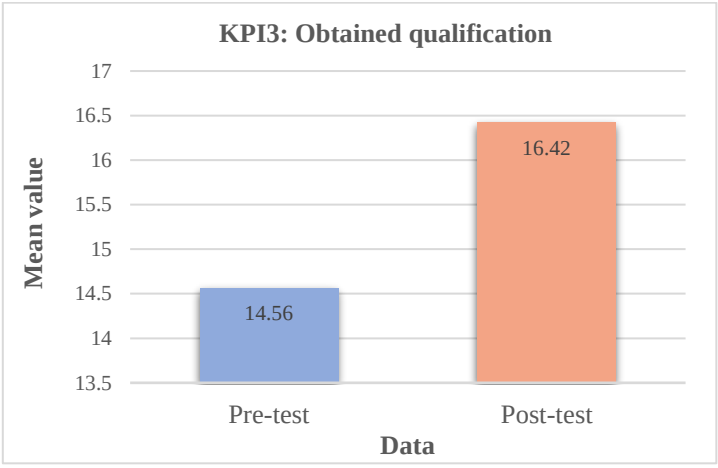

Figure 13. KPI3 pre- and post-test graph, quantified as a score from 0 to 20

Figure 14 shows that the significant value in the pre-test is less than 0.005 and in the post-test the significance value is less than 0.005. Therefore, it is considered a non-normal distribution. Table 12 shows that, after having carried out the non-parametric Wilcoxon test, the value of significance is less than 0.001, this value is less than the limit to accept the research hypothesis, thus being able to affirm that an educational video game significantly influences the application of learning.

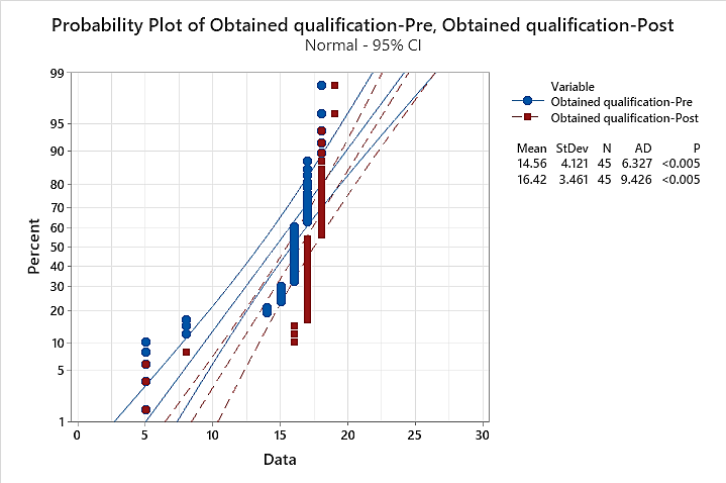

Figure 14. KPI3 normality test plot

Table 12. Wilcoxon test of KPI3

Test statistics[a]	
	Obtained qualification-pre Obtained qualification-post
Z	-3.630[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon signed ranks test
b. Based on negative ranks

3.4. Comparative interpretation

3.4.1. For KPI1: grade of motivation

The results obtained through the statistical tests, where the significance value was 0.031, show that there was an improvement of 12.9%, determining that an educational video game significantly influences learning motivation. The authors in their article [28] coincide with the results obtained since they indicate that after having obtained data from 111 students, it is evident that there is a positive influence of gamification on the motivation of student activation, where a significance value is less than 0.01. Likewise, the authors in their article [29] coincide with the results obtained, since they indicate that after having obtained the data of 249 students, it is evident that there is a positive influence of gamification on motivation in university teaching, where an 84.3% consider that it is a very motivating tool.

3.4.2. For KPI2: acquired knowledge

The results obtained through the statistical tests, where the significance value was less than 0.001, show that there was an improvement of 46.34%, determining that an educational video game significantly influences the acquisition of learning. These results coincide with the article [30], where it is indicated that after having carried out an analysis of 18 students, it is evident that there is a positive influence of gamification on learning, where learning progress of 82.35% is evidenced. Likewise, these results coincide with the article [31] where they indicate that after having carried out an analysis of 321 students, it is evident that there is a positive influence of gamification on learning, where learning progress of 72.9% is evidenced based on academic results from one semester to another.

3.4.3. For KPI3: obtained qualification

The results obtained through the statistical tests, where the significance value was less than 0.001, show that there was an improvement of 12.77%, determining that an educational video game significantly influences the application of learning. These results coincide with the article [32] where it is indicated that after having carried out an analysis of 121 students, it is evident that there is a positive influence of the gamification processes on academic performance, where a percentage greater than 54% of the students was obtained. students who pass the course. These results also coincide with the article [33], where they indicate that after carrying out an analysis of a total number of 295 students, it is evident that there is a positive influence of gamification on academic performance, where 79.4% of approved students were obtained.

4. CONCLUSION

After completing this investigation, and considering the results obtained, it was determined that an educational video game significantly influences motivation, acquisition, and application of learning. This is concluded from the following results obtained: there was an increase in the grade of motivation of 12.9%, there was an improvement in the acquired knowledge indicator of 46.34% and an improvement in the obtained qualification indicator of 12.77%

Regarding the contribution of the research, the agile methodology was used for the development of the project, this being effective for the group of students since the finished products were constantly evaluated by the interested party and adjusted to their particular needs. In addition, it is favorable to monitor the performance of students when using video games. For this reason, a connection to the PlayFab services, which belongs to Azure, was implemented in the project, which allows capturing the results of the interaction of the students with the video game.

It is important to highlight that the classes that take place in the school are face-to-face and the students are not used to this new reality, this is a difficulty when collecting data from the indicators since some students did not know how to use Google Forms program. Other students presented connectivity problems at the time of entering through the cell phone and they had to be placed at another time to complete the investigation due to the time that the teacher established to carry out the investigation. Despite the limitations presented, solutions were sought that would allow the research to continue, one of them being the preparation of a user manual for the student. It is recommended for future research to survey the people who will use the system, to know the technological resources they have and their preferences when using the system.

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BIOGRAPHIES OF AUTHORS

Alejandro Cachay-Gutierrez is Engineer in Computer Systems Engineering from the Universidad Privada del Norte - Peru, with experience in software project development, Help Desk and management of information technology resources for improving processes in an organization. He has worked in the Department of Information Technology improving business processes, productivity business, and systems auditing for the Higher School of Public Artistic Training "Fine Arts" of Trujillo, Peru. He can be contacted at email: cachayalejandro@gmail.com.

Michael Cabanillas-Carbonell is Senior member IEEE. Engineer and Master in Systems Engineering from the National University of Callao - Peru, PhD candidate in Systems Engineering and Telecommunications at the Polytechnic University of Madrid. President of the chapter of the Education Society IEEE-Peru. Conference Chair of the Engineering International Research Conference IEEE Peru EIRCON. Advisor and Jury of Engineering Thesis in different universities in Peru. International lecturer in Spain, United Kingdom, South Africa, Romania, Argentina, Chile, China. Specialization in Software Development, Artificial Intelligence, Machine Learning, Business Intelligence, Augmented Reality. Reviewer IEEE Peru and author of more than 60 scientific articles indexed in IEEE Xplore and Scopus. He can be contacted at mcabanillas@ieee.org.