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Abstract

The proposed research seeks to develop the relationship between gamification tools and learning the subject of mathematics in systems engineering students. It is developed through the quantitative approach, from a correlational approach, the method developed is pure experimental type, in which a control group and another experimental group are used to whom an instrument is applied before the manipulation of variables, after applying the treatment to one of the groups a post test is applied. There was a population of 180 students and a non-probabilistic sample of 28 students distributed in an experimental group. The survey technique was used to measure the variables and the questionnaire was used as an instrument, which was validated by means of expert judgment and reliability by means of the Kuder-Richardson 20 statistic (0.721 and 0.769 high reliability). The descriptive statistics yielded favorable results in the mean (Pretest=7.17 and Posttest= 16.14). The inferential statistics allowed us to prove favorably that gamification tools influence learning in the area of mathematics in first cycle systems engineering students (Tobt =20.4 >Tcri= 2.017).

Key words: Gamification, mathematics, learning, tools.

1. Introduction

In the present context of a global world in which technological advances predominate, where technology and especially the use of the Internet in its different forms continue to change the way society develops with respect to work, communication and also the educational system. Therefore, the teaching place must be transformed into a different environment of active knowledge, a moment where the participant takes advantage of the information provided through the new technologies and is given the opportunity to acquire them even when the participant has limitations of different types.

The question arises: What is the relationship between Gamification Tools and the learning of the subject of mathematics in students of the I cycle of Systems?

2. Background, literature review, state of the art

According to Zabaleta et al. (2021) gamification techniques are one of the main pillars that have shown the best results in higher education institutions. In this way, a program of teaching strategies was developed through gamification tools in such a way that professional competencies were strengthened; this was developed in the interdisciplinary support of systems engineering programs. What was developed was an action research through the survey instrument that managed to reach the perception of 24% of those who make up the student community, and was translated into 66 students. As a result, it was found the need to update the methods in the institutions dedicated to education in accordance with the competencies that technology provides.

For Hernández Ramos et al (2018), in his study on Gamification within the university, where he evaluates the use of a preparade methodology with gamified teaching using the Kahoot tool in the case of higher education for which smartphones play an important role. A non-experimental research of descriptive scope and the use of an electronic questionnaire to 241 students is proposed. As a result, the relevance of the students is obtained by assessing said tool through a self-evaluation.

Kahoot: It is the most widely used application for the creation of online questionnaires. It is visually attractive and contains thousands of public questionnaires of many subjects, which can be edited to adjust them to the customized content. The questions can be uploaded and incorporate images such as YouTube videos.

Socrative: It is a more serious application for the creation of quizzes is versatile and allows, in addition, to create quizzes using a spreadsheet that is then uploaded to the website generating the quiz automatically.

Quizlet: This application is not as visually attractive as kahoot, nor as versatile as socrative, but it has the potential to synchronize with Google Classroom.

3. Materials and methods, methodology

Research approach

The approach is quantitative.

Method

The scientific method (hypothetico-deductive) will be used, since it begins with the identification and formulation of the problems, objectives and hypotheses; then the research instruments are elaborated and applied to the sample, the data are obtained and statistically processed for hypothesis testing.

Type of research

The type of research will be experimental, in this sense it is oriented to demonstrate the effectiveness of teaching with gamified tools.

Research design

The design used in the research is the "pre-experimental", specifically the so-called "before and after design with an experimental group" is useful to determine if there were changes in the behavior of the individuals in the sample between their initial state, measured by the Pre-test or Entry Test, and the subsequent situation, measured by the Post-test or Exit Test.

GE : O1	X	O2

Where:

X = Experiment.

GE = Experimental group.

O1 O2 = Observation of entry and exit to the experimental group.

Experimental group: The gamified tools will be applied to this group to verify the use of this technology.

The following table shows the design that will be used:

To test the hypotheses will be used: Student's t-test.

The purpose of the post-test will be to establish whether significant differences are generated in the group at the end of the experimentation. If the use of the gamified tools is successful, there should be statistically significant differences in the group.

Population

The population or universe is made up of all the students of the fifth cycle of Systems Engineering students of the Universidad Nacional Federico Villarreal, which are approximately 100 students.

The sample

The sampling technique to be used is non-probabilistic, intentional. According to Hernández et al. the non-probabilistic or directed sample is a "Subgroup of the population in which the choice of the elements does not depend on probability but on the characteristics of the research" (2010, p. 176).

Techniques and instruments

For the present study, the instruments that have been identified will be used, which will allow collecting information and measuring the variables to determine the measurement of the variables and establish the corresponding correlations and comparisons.

The instruments to be considered are:

Observation Cards.

Written exams. (Pre Test and Post Test)

Statistical treatment

Which will allow describing the data, values or scores obtained for their interpretation.

Descriptive statistics will be used for the figures and statistical tables and inferential statistics for the hypothesis test.

Statistical procedure

The reliability or trustworthiness of the instruments will be tested if they are useful for the purpose and to apply them in the research.

The reliability of the instruments will be tested using the Kr 20 statistic (Kuder Richarson 20), since they are dichotomous instruments that measure performance.

$$\rho_{KR20} = \frac{k}{k-1}\left(1 - \frac{M(k-M)}{k\sigma^2}\right)$$

The hypothesis tests will be carried out using the parametric statistic Student's t-statistic because the sample is smaller than 30 and the data are quantitative.

$$t_{Obtenido} = \frac{(X_1 - X_2)}{\sqrt{\frac{S^2_1 + S^2_2}{n}}}$$

In order to contrast the hypotheses, a comparison will be made of the averages or means of the scores achieved in the Experimental Group; the statistic to be applied will be the parametric one.

4. Elaboration of the proposal

Table 1

Expert Judgment Rating

Expertos	Calificación
Dr. Adrián Quispe Andia	**82.00**
Dr. Juan Carlos Huamán Hurtado	**80.00**
Dra. Jady Luz Vargas Tumaya	**81.00**
Promedio	**81.00**

Source: Own elaboration

Reliability of the instruments

The reliability criterion of the instruments is determined by the K-Richardson 20 coefficient; it requires only one administration of the measuring instrument and is applicable in knowledge tests or when the instrument has dichotomous items in which there are two possible answers.

Table 2

Reliability criteria values According to Guilford

Escala	Categoría
0 - 0,20	Muy Baja
0,21 - 0,40	Baja
0,41 - 0,60	Moderada
0,61 - 0,80	Alta
0,81 - 1	Muy Alta

The formula for the K-Richardson 20 reliability statistic:

$$kr20 = \frac{k}{k-1}\left[\frac{S^2 - \sum p*q}{S^2}\right]$$

Where:

S2 variance of the test scores.

p proportion of correct answers

q proportion of incorrect responses

k total number of test ítems

Using Microsoft Excel 365 Statistical Software, the K-

Richardson 20 reliability of the input-output test was obtained.

a). Entrance Test Reliability

The entrance test instrument was applied to a pilot sample of 10 students of systems engineering of the I cycle to see the domain in the area of mathematics.

Table 3

Summary of input data processing

n	item1	item2	item3	item4	item5	item6	item7	item8	item9	item10	item11	item12	item13	item14	item15	item16	item17	item18	item19	item20	TOTAL
1	1	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	1	1	1	1	16
1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	1	1	16
3	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	19
4	1	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	16
5	1	0	0	0	1	0	0	1	1	0	1	0	1	0	1	1	0	1	1	1	11
6	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	17
7	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
8	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	18
9	1	1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	11
10	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	15
RC	10	8	9	7	9	6	2	8	6	6	10	8	8	7	10	8	7	8	10	10	7.567
RI	0	2	1	3	1	4	8	2	4	4	0	2	2	3	0	2	3	2	0	0	
P	1	0.8	0.9	0.7	0.9	0.6	0.2	0.8	0.6	0.6	1	0.8	0.8	0.7	1	0.8	0.7	0.8	1	1	
q	0	0.2	0.1	0.3	0.1	0.4	0.8	0.2	0.4	0.4	0	0.2	0.2	0.3	0	0.2	0.3	0.2	0	0	
p*q	0	0.16	0.09	0.21	0.09	0.24	0.16	0.16	0.24	0.24	0	0.16	0.16	0.21	0	0.16	0.21	0.16	0	0	2.65

Replacing data: Kr20 = 10/9 x ((7,567-2,65) / 7,567) = 0.721

Comment

The result obtained for the Kuder-Richardson 20 coefficient is equal to 0.721. This means that the instrument presents high reliability because it is on the 0.61 to 0.80 scale. Therefore, this instrument presents internal consistency.

b). Reliability of the Exit Test

The exit test instrument was applied to a pilot sample of 10 students of systems engineering of the first cycle, in order to see the mastery in the area of mathematics.

Table 4

Summary of output data processing

n	item1	item2	item3	item4	item5	item6	item7	item8	item9	item10	item11	item12	item13	item14	item15	item16	item17	item18	item19	item20	TOTAI
1	1	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	1	1	1	1	16
1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	1	1	16
3	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	19
4	1	0	1	0	0	1	0	0	0	0	1	1	1	1	1	1	0	1	1	1	12
5	1	0	0	0	1	0	0	1	1	0	1	0	1	0	1	0	0	1	1	1	10
6	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	1	1	1	1	1	16
7	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
8	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	18
9	1	1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	11
10	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	15
RC	10	7	9	7	8	6	2	7	5	6	10	8	8	7	9	7	7	8	10	10	9.656
RI	0	3	1	3	2	4	8	3	5	4	0	2	2	3	1	3	3	2	0	0	
P	1	0.7	0.9	0.7	0.8	0.6	0.2	0.7	0.5	0.6	1	0.8	0.8	0.7	0.9	0.7	0.7	0.8	1	1	
q	0	0.3	0.1	0.3	0.2	0.4	0.8	0.3	0.5	0.4	0	0.2	0.2	0.3	0.1	0.3	0.3	0.2	0	0	
p*q	0	0.21	0.09	0.21	0.16	0.24	0.16	0.21	0.25	0.24	0	0.16	0.16	0.21	0.09	0.21	0.21	0.16	0	0	2.97

Replacing data: Kr20 = 10/9 x ((9.656-2.97)/9.656) = 0.769

Comment

The result obtained for the K-Richardson coefficient is equal to 0.769; this instrument has a high reliability because it is on the 0.61 to 0.80 scale. Therefore, the instrument presents internal consistency and is applicable.

Presentation and Analysis of Results

A. Application of the baseline and exit tests of the experimental group

Table 5 is the result of the application of the baseline and exit tests of the experimental group.

Scale

Escala	Cualitativa
0-10	Deficiente
11-12	Regular
13- 16	Bueno
17 - 20	Excelente

Source: Own elaboration

Table 6

Evaluation results

Experimental Group: Students of the First Cycle of System Engineering

Alumno	*Prueba de Inicio*	*Salida*
1-28 Promedio	**7.17**	**16.14**

Commentary:

It is observed, that the average of the start evaluation of the experimental group was 7.17 (Poor) and the average of the exit evaluation was 16.14 (Good), which shows the favorable influence in the learning of the mathematics area with the Gamification Tools in the I cycle system engineering students.

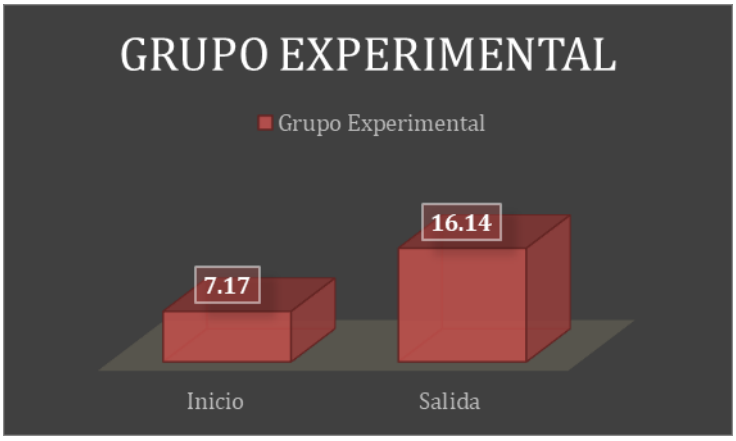
Table 7

Comparison of the averages of the start and exit exams of the experimental group.

Grupos	**Inicio**	**Salida**
Grupo Experimental	7,17	16,14

Source: Own elaboration

Figure 1 Analysis of comparison of means of the experimental group in start and exit.



Source: Own elaboration: Own elaboration

Comments:

According to Figure 1, it can be observed in the exit or post-test the difference of means that there is between the students of the fifth grade of the experimental group which is 16.14, compared to the start or entry which was 11.54 in terms of the average of the two tests administered to the group.

Table 8

Statistics of the Dependent Variable: Learning in the area of mathematics

Estadísticos descriptivos	GE Inicio	GE Salida
Media	7.17	16.14
Mediana	7.5	16
Moda	8	17
Desviación estándar	1.5647	1.177388
Varianza de la muestra	2.4484	1.386243
Rango	5	4
Mínimo	4	14
Máximo	9	18
Muestra	28	28

Source: Own elaboration

B. Normality Test

Before performing the respective hypothesis test we will first determine whether there is a normal distribution of the data (parametric statistics) or not, i.e. a free distribution (non-parametric statistics). For this purpose we will use the ShapiroWilk normality test (n<50).

Table 9

Shapiro-Wilk Normality Test

Normality tests

	Shapiro-Wilk		
	Estadístico	gl	Sig.
GE-INICIO	0,879	28	0,064
GE-SALIDA	0,914	28	0,054

*. This is a lower bound of true significance.

a. Lilliefors significance correction.

Source: Own elaboration

To determine whether the distribution of our sample data is parametric we have to establish:

H0: The data come from a normal population. (sig > 0.05)

H1: The data do not come from a normal population. (sig <=0.05)

Now our significance level is 5%, it is equivalent to 0.05 and if: Asymptotic Sig. (bilateral) of the table is greater than the significance level 0.05, then the null Hypothesis (H0) is accepted, and the Alternate Hypothesis (H1) is rejected. Therefore: it is determined that our data fit a normal curve and a parametric test can be used for hypothesis testing, in our case Student's t-test.

C. Hypothesis Testing

The statistical method to test the hypothesis was the comparison of means and Student's T because it is a test that allowed measuring quantitative aspects of the answers obtained from the instrument administered and measuring the influence that exists of one the two study variables with respect to the other.

Comparison of means:

{ x1, x2}

X1: experimental group Start

X2: experimental group Exit

The difference of means X2 - X1= 16,14 - 7,17= 8,94 = 9

The difference of means in the control and experimental groups is significant.

General Hypothesis Test

a) Hypothesis Statement

HG: The gamification tools have a significant impact on the learning of the mathematics area in the students of systems engineering of the I cycle.

H0: Gamification tools do not have a significant impact on learning in the area of mathematics in I cycle systems engineering students.

b) Confidence level

95%

c) Significance Level

α=0.05 = 5% α/2=0.025

d) Choice of Statistic

Since the variances are unknown, and unequal; also n 30 , then we apply the following formula:

$$t_c = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{(n-1)S_1^2 + (m-1)S_2^2}{n+m-2}}\sqrt{\frac{1}{n} + \frac{1}{m}}}$$

Where:

Tc : "t" calculated

$\overline{X}_1$ Average of the first group

$\bar{Y}_2$ Average of the second group

S_1^2 Variance of the first group

S_2^2 Variance of the second group.

n : Sample size of the first group

m : Sample size of the second group.

Table 10

Dependent simples

Two-sample t-test assuming unequal variances

	GE Inicio	*GE Salid*
Media	7,17	16.14285
Varianza	4.33201058	1.386243
Observaciones	28	28
Diferencia hipotética de las medias	4.61	
Grados de libertad	54	
Estadístico t	-20.4	
P(T<=t) una cola	4.9288E-24	
Valor crítico de t (una cola)	1.6810707	
P(T<=t) dos colas	9.8575E-24	
Valor crítico de t (dos colas)	2.017	

According to the result of the obtained processing, the calculation of the obtained t and critical t statistics is performed, from the data obtained by the independent groups (control and experimental) in the output. From where we obtain the value of t obtained = -20.4 (value obtained from the sample data); and the value of critical t= ±2.017(value obtained from the Student's T table with 0.25% of significance level for 2 tails).then: As :t obtained>t critical , for (2 tails) .that is: -20.4 >2.017 20.4>2.017

5. Discussion

The results of the research demonstrate a significant influence of gamified tools that significantly impact on the ability to reason and argue mathematical ideas in the area of mathematics in the students of systems engineering of the I cycle. The results of the research demonstrate the effectiveness of the gamified tools given that in the entrance test the average is equal to 11.53, and in the exit test it is 16.14 in such sense, the students when using the gamified tools, present a better level of learning.

6. . Conclusions

1. Based on the results obtained, it was concluded at a 95% confidence level that the use of gamification tools has a significant impact on learning in the area of mathematics in first cycle

systems engineering students, as demonstrated by the contrast of hypotheses (T-calculated=-20.4 falls in the acceptance zone of the General Hypothesis) and the discussion of results.

2. Based on the first specific hypothesis of the research, it is concluded at a 95% confidence level that the application of gamification tools has a significant impact on the ability to mathematize situations in the area of mathematics in systems engineering students of the first cycle, as demonstrated by the contrast of hypotheses (T-calculated=- 47.05 falls in the acceptance zone of Hypothesis H1) and the discussion of results.

3. Based on the second specific hypothesis of the research, it is concluded at 95% confidence level that the application of gamification tools has a significant impact on the ability to communicate and represent mathematical ideas in the area of mathematics in I cycle systems engineering students, as demonstrated by the contrast of hypotheses (T-calculated= 47.06 falls in the acceptance zone of Hypothesis H2) and the discussion of results.

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Computer and IT engineer with experience in the banking and finance sector, in the area of customer service. Extensive performance in the area of academic coordination, follow-up, training and teaching monitoring at university level. Management of virtual educational platforms and videoconferencing. Technological skills in different computer tools. Candidate for a Master's degree in Education with a specialisation in virtual teaching. Strong organisational skills, adaptability, task planning, communication skills, staff management, teamwork and problem solving.

EDITH ELVIRA GUTIERREZ ZUBIETA

Degree in education in the specialty of English and master's degree in education, with a mention in university teaching, obtaining international certification from the British Educational College in the command of the English language.

More than 21 years of experience as a teacher and coordination of the academic area in private institutions, development of projects on levels of the English language, having vast experience in the preparation of international Cambridge exams such as CAE, FCE, PET; KET, experience in the chair at national and private universities.