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Analyzing the gender influence on the interest in engineering and technical subjects

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Abstract This paper studies the impact of gender on the interest in engineering and technical subjects of the students in the first courses of secondary education. A statistical analysis was carried out, analyzing the use of a free virtual-reality application, developed by the 3M Foundation, which aims to bring these subjects to the students. Non-parametric statistical methods were used to analyze several variables, such as repetition of the experience, new learning and knowledge reinforcement as well as learning in different ways, which were collected through two questionnaires. These were *Pre* and *Post* the playing of the game and later, subsequently validated. This analysis demonstrated that gender has an impact on the interest of the students in engineering and technology but it does not have any influence on the rest of the studied variables. The results show that the interest of girls could be increased through group activities. Age has only influence on the desire to repeat the experience, with a varied level of influence, in the case of the technological contents. The motivational factors that have a greater influence on each variable, "innovation" and "usefulness", were also analyzed.

Keywords Technology · Engineering · Education · Gender · Technical Education

1 Introduction

Research explains that teachers at primary school often deal with gender stereotypes related to learning styles and abilities. Certain aspects of the mandatory secondary education system exist, which can lead to a belief in specific stereotypes (Boujaoude 2011). As a result, a negative influence can be observed while looking at the competences and attitudes apparent when deciding what men and women might prefer to study (Saínz 2011). The gender

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stereotypes suggest that certain subjects in higher education are chosen either by men or women (UNESCO 2017; USPTO 2019) and, there are a lack of feminine references to inspire other women to take up these disciplines (Griffith 2010).

In most western countries, for many years, women have mostly chosen biology and health courses, meaning a lower presence in engineering and technological courses (Simpkins et al. 2006). A recent report in Spain (Digitales 2018) on women's participation in the digital economy, concludes that women are progressively choosing less courses related to Information and Communication Technology (ICT), and consequently, their participation in these areas does not grow at the required rate. The number of people who choose engineering or technological studies is decreasing. With regards to women, in 2015 and 2017 they represented 16.1% and 14.6% of the people that carried out these types of studies, respectively. The data of the Ministry of Education, Culture and Sports (Ministry of Education & Sports 2019) support this tendency, showing a decrease in the number of enrolled students within university engineering courses. These statistics also express a far more significant reduction among women.

Due to the above, it is expected that the number of professionals in engineering and technology fields will not be substantial enough for the potential challenges of the future. In Spain, according to a recent survey (Digitales 2019), it is estimated that during 2017-2022 there will be around 1,250,000 jobs in this sector and many of them will remain vacant. Because of this fact, most companies nowadays consider it necessary to promote a vocation in engineering and the technological fields from as early as primary and secondary schools. The need to foster an engineering career is also included in the report of the Royal Engineering Academy (Cavero & Ruíz 2019). Therefore, implementing a higher level of interest in the engineering and technological areas within schools is required. This should be done for the purpose of finding and inspiring new individuals to be enthusiastic about studying these subjects, with a particular focus on women.

The research described in this document aims to encourage girls that are in the first stage of mandatory secondary education system (ESO) in Spain to take a greater interest in engineering and technology disciplines. A virtual-reality game is used as a means to introduce these disciplines to the students and to make them more appealing to girls. Specifically, the goals of this research are:

- Building of an educational virtual-reality game containing elements of engineering and technological areas for the first stage of ESO.
- Execution of a quasi-experimental study to know if significant differences in some variables exist. This was carried out before and after playing the game, and, analyses whether results depend on the user's (gender and age). A statistical study of several variables was undertaken (percentages per band, median, mode and testing of hypothesis).

Regarding video games, several authors agree that these forms of entertainment can improve the quality of education (Bekebrede & Warmelink 2011; Sailer et al. 2013), seeming to be a useful tool in order to provide an efficient environment for learning (Clark & Ernst 2009). Relationships between gaming and learning exist, which can be shown through knowledge gains associated with video game play, with the cooperative video games seeming to be more effective in the acquisition of knowledge (Ke & Grabowski 2007). The 3-D virtual world learning environment enables students to have an interactive experience that not only helped achieve learning outcomes but also surpassed course goals (Gee 2007). It has been shown that educational video games contribute to both mental and calculated learning (Del Moral et al. 2016) and that video games designed to teach mathematics help to create more students with a positive attitude towards it (Huang & Ke 2009). The improvement of the student learning experience and motivation through the use of on-line physics content has been also proven (Rose et al. 2016). Considering all the above, the use of an educational video game with engineering and technology components would help to increase the knowledge and the interest in these subjects by girls enrolled in ESO courses. It would be helpful for promoting that more women consider dedicating themselves professionally to these fields in the future.

In Spain, ESO, whose students are aged between twelve and sixteen, is organized in fields and consists of a first stage (with 1^{st}, 2^{nd} and 3^{rd} year courses) and a second stage (with 4^{th} year courses). In both stages, students should develop abilities through practice-oriented teaching methods, combining the knowledge and content of each course. However, our application, as we have already pointed out, has been designed to be used by students in 1^{st}, 2^{nd} y 3^{rd} courses of ESO. For 1^{st} and 2^{nd} year courses, the content includes organization and technological planning, obtaining materials and recycling them, the description of the various steps in a technical project, fundamentals of group work, history and evolution of technology, and finally, the description of how an academic project should be presented. The 3^{rd}-year courses includes content such as an analysis of the technological problem-solving process, the study of different types of hardware and operating systems, the development of speaking and writing skills, presentation of the fundamentals of electricity and communication technologies.

This paper is organized as follows: firstly, material and methods are presented, explaining, in detail, the type of study, the resources and the methods of analysis employed. It goes on to focus on the developed software programs, the sample selection, and finally, the undertaking and reporting of the analysis of data. Afterwards, the results, conclusions and future projects are presented and discussed.

2 Material and Methods

In this section we describe the type of study as well as the analysis of resources and methods used in our research.

2.1 Overview of the type of study employed

This analysis was a quasi-experimental study, without a control group. It aimed to compare results by initially applying a pre-test, then introducing the virtual reality video game as an intervention and following this up by carrying out a post-test to the same group in order to determine the occurred variations. There are many reasons to use the video games as a learning tool, such as their easy accessibility, uncomplicated content, ability to be updated and edited, high customization level, and finally the availability of eyecatching graphs in order to captivate the students, engaging them in the activities. The video games are often considered as entertainment by the students (Girard et al. 2013), which achieves an unconscious form of learning, an assimilation of contents and an acquisition of capacities. In such a way, students take pleasure taking part with little effort (Osma-Ruiz et al. 2015). Quasi-experimental studies have also been widely used in various fields of education in order to evaluate learning strategies (Furtak et al. 2012; Otte et al. 2019). Research suggests that the use of educational computer games or video games increases learning and engagement during a lecture (Annetta et al. 2009; Broma et al. 2011). Specifically, we aim to answer the following research questions before running the game:

- What is the motivation level of the students for engineering and technology areas? Does it depend on their gender or their age?
- What is the level of knowledge of the students regarding engineering and technology topics?
- Is there any correlation between motivation for the engineering and technology areas of students and the knowledge level that students already possess?

After running the game:

- Has the video game enabled the students to increase their knowledge already acquired or to reinforce it? Is there any difference according to gender or age?
- To what extent would students repeat the experience? Does it depend on gender or age?
- Did the interest related to engineering and technology areas of students change? Is this change different according to gender or age?

2.2 Overview of used resources for the study

The resources used were: the video game, a Playstation 4 Pro console, three controllers, an audiovisual playback device (television screen or projector) and a virtual reality Playstation kit. The kit included virtual reality glasses along with a device to connect them to the Playstation, a camera, as well as a tripod to track the movements of the virtual reality player and an audiovisual reproduction device.

The video game is a free use virtual-reality application, implemented by the 3M Foundation, named STEM+VR=YOU MAKE IT REAL. It was specifically designed for a PlayStation 4 platform, since it is a well-known reference in the world of video games and it has a simple virtual reality device. This application was developed by using the UNITY engine version 2018.1, which allowed the design of levels and interfaces as well as program of the logic using the C# language. We decided to use UNITY as the development platform because it is the facto standard for the creation of video games. Furthermore, it is well-documented and possesses a cross-platform capacity (one of which is the PS4 system). Moreover, most elements and scenarios were designed through 2D and 3D design programs, such as Autodesk 3D Studio Max and Adobe Photoshop. A third person option was chosen for the dialogues between the game's characters. The game can be played with a console and with virtual reality glasses. The application was designed to be played by groups of three. However, it is possible for larger groups of users to play, although with a lower level of participation. The video game presents content divided into 3 modules for the 1^{st} and 2^{nd} courses for both engineering and technology disciplines. The 20-minute experience allows the user to select one of three modules, which refers to a specific discipline and module, as shown below:

- Block/Experience: Technology
  - Module:sustainability, recycling
  - Module: manufacturing process
  - Module: Inside a computer
- Block/Experience: Engineering:
  - Module: graphic expression: scales of measurement
  - Module: structure and mechanism: types of forces in physics
  - Module: electric circuit

All experiences have the same structure: initially, there is an explanation on the content, and after, the users should meet a challenge, in video-game experience format. The experience includes a robot "Pi", which is the character that leads the experience. Once the three modules of each block are completed, the experience is restarted and users can perform another block or conclude the experience. At the end of each block, "Pi", provides a final explanation to the participants, encouraging them to be interested in engineering or technology disciplines.

2.3 Overview of methods of study used

In this subsection we present the design of questionnaires, the statistical study, the software programs and the sample selection. The undertaking and reporting of the analysis of data are also presented.

Design of questionnaires

Each participant in the activity completed two questionnaires, one before (*Pre*) and another after (*Post*) involvement in the game. The objective was to check if differences in relation to certain attitudes existed. For both types of questionnaires several activities were carried out. The first activity consisted of the preparation of the initial questions. The following step was the establishment of the way in which the questions should be evaluated. Once the questionnaires were completed, the next stage was to select the most appropriate questions for the study, making a correlational analysis of the provided answers, calculating the Corrected Homogeneity Index, CHI. Later, an estimation of the Reliability Coefficient, RC, was also carried out.

A four-level scale was used to score each question. This type of scale did not offer the option of a neutral opinion. Therefore, the students were forced to make a definitive decision.

The Pre questionnaire contained the following general questions about the surveyed student:

- How old are you?
- What is your gender?
- What is your school?

The questions presented below were answered according to the following Likert scale:

- 1 star (0%, very low),
- 2 stars (30%, low),
- 3 stars (67%, high),
- 4 stars (100%, very high)

Regarding technology:

- How much do you know about recycling?($PreA_{11}$)
- How much do you know about manufacturing processes? ($PreA_{12}$)
- How much do you know about the inside of a computer? ($PreA_{13}$)
- How much does this block motivate you? ($PreA_{1}$)

Regarding engineering:

- How much do you know about the scales? ($PreA_{21}$)
- How much do you know about the types of strengths? ($PreA_{22}$)
- How much do you know about electrical circuits? ($PreA_{23}$)
- How much does this block motivate you? ($PreA_{2}$)

The *Post* Questionnaire consists of the following questions:

- Would you repeat the experience? ($PostA_1$)
- Have you learned and reinforced the knowledge already acquired? ($PostA_2$)
- Do you think that the scientific-technological subjects would be interesting to work on more in the future? ($PostA_3$)
- Do you think that with these types of activities you can learn in a different way? ($PostA_4$)
- Which of the two blocks have you experienced?

Statistical study

The correlation between both *Pre* and *Post* variables was calculated in order to measure the strength and direction of relationships between them.

Two adaptive motivational factors were also studied (”innovation” and ”usefulness”), based on Personal Investment Theory (PIT) (King et al. 2018) to use the application. $PostA_2$ for ”innovation” and $PostA_4$ for ”usefulness”.

As these Likert scales were ordinal, it was not suitable to compute the mean and standard deviation of the *Pre* and *Post* variables (Gelph 2019). Therefore, an estimation was made of the percentage of people in each band 0% (very low), 33% (low), 67% (high) and 100% (very high) for all variables. The mode and median were also calculated.

The influence of gender, observations of the same *Pre* or *Post* variable were available in two different populations, one M (boys) and other W (girls). The values of *Pre* and *Post* variables in each band (very high, high, low, very low) were analyzed. A testing of hypothesis of *Pre* and *Post* variables was also carried out, where:

Null hypothesis (H_0): “The gender of the students does not affect sigficantly to the variable”.

Alternative hypothesis (H_a): ”The gender of the students influences the variable”.

Since we were working with an ordinal Likert scale, a statistical analysis (Neuhauser 2017) was implemented using non-parametric methods. Such methods required the fulfillment of two conditions, where the sample was representative of the population under study, and in which the observations were independent. As an hypothesis test we carried out the Wilcoxon-Mann-Whitney test, and we calculated the value of p-value with a confidence interval of 0.95. Since Wilcoxon-Mann-Whitney test required homogeneity of variances, we verified this by applying the Fligner-Killeen test, with a confidence interval, α, equal to 0.95.

Regarding the age influence, the existing 4 age groups, 12, 13, 14 and 15 year olds were considered for implementing a hypothesis test, where:

Null hypothesis (H_0): “All samples come from the same population, and have the same distribution”.

Alternative hypothesis (H_a): “At least one sample comes from a population with a different distribution”.

Again, the statistical analysis was implemented using non-parametric methods, which required compliance with the two conditions indicated above. As an hypothesis test we applied the Kruskal-Wallis test, calculated the value of p-value, for a confidence interval, $\alpha = 0.95$. In the case that H_0 is rejected, pairwise comparisons were made with the Mann-Whitney U test with Bonferroni correction.

Software programs

For the calculation of the CHI, the RC and the conduct of the statistical study several programs in R (R, 2019) were codified, employing R.3.6.0 version. The graphics were built using the Likert package.

Sample selection

The target population was defined as students of 1^{st} and 2^{nd} ESO belonging to educational institutions of the Community of Madrid. Only those students that agreed to participate.

Undertaking and reporting of the analysis of data

Initially the students answered the *Pre* questionnaire. The next step was the execution of the video game. In most cases, the virtual reality kit was sent to the schools for the students to do the activity on their own, since they could assemble the kit, start and carry out the activity following simple instructions without any external support. In other cases, 3M Foundation volunteers went to the schools to start the activity. In both situations, the work plan was as follows:

– Participation in a small group of 3 members. Each student played for 20 minutes, and usually the preparation process (putting on the glasses, reading instructions, etc.) took 10 minutes. The group had to complete all modules of a block. During the completion of each module, all players had a remote control but only one of them wore the glasses. The player wearing the glasses has a set of powers made up of "special clues" that they must share with the rest of players. In order to solve the task, the players had to interact with each other and work as a team.
– Participation in a large group between 10 and 30 members, resulting in the management of the activity being extremely complex. In this method students played in the same way as they would in a small group with a player wearing the glasses and using the remote control, while the other two players had only a remote control. The rest of the students sat behind them watching the game. It was important that the team members worked together in order to achieve an enriching experience for the team.

Despite the fact that only those members who handled the controls were the active players, all challenges had to be solved by the whole team. The glasses were passed between the three active players for the completion of each module in a block. Once a module in a block was finished, the active players were changed for three other students from the non playing group.

One of the school teachers was also present during the process of the activity in order to encourage good behavior by the students and to enable them to obtain a greater benefit from the experience. The duration of the activity was between 1 and 6 hours, with a break after three hours of playing. In the final step, the students answered the *Post* questionnaire.

3 Results and Discussion

The characterization of the sample, according to gender and age, can be observed in Tables 1 and 2, for the *Pre* and *Post* questionnaires.

Table 1 Distribution of individuals who participated in the study (178 students), according to gender (girls, boys) and age (12, 13, 14 and 15 year olds)

Individuals	Girls	Boys	12 year olds	13 year olds	14 year olds	15 year olds
178	85/178 (47.75%)	93/178 (52.25%)	55/178 (30.90%)	79/178 (44.38%)	32/178 (17.98%)	12/178 (6.74%)

Table 2 Distribution of individuals in the total sample (178 students (85 girls, 93 boys)) who made use of the technology (129 of 178 students) and the engineering (49 of 178 students) experiences, according to gender (girls, boys) and age (12, 13, 14 and 15 year olds)

	Individuals	Girls	Boys	12 year olds	13 year olds	14 year olds	15 year olds
Technology	129/178 (72.47%)	67/85 (78.82%)	62/93 (66.67%)	43/129 (33.33%)	54/129 (41.86%)	25/129 (19.38%)	7/129 (5.43%)
Engineering	49/178 (27.53%)	18/85 (21.18%)	31/93 (33.33%)	12/49 (24.49%)	25/49 (51.02%)	7/49 (14.29%)	5/49 (10.20%)

The CHI, in the Tables 3 and 4, was greater than 0.20 for all questions, hence, it was not necessary to eliminate any questions. Both questionnaires had sufficient reliability since the value of RC was 0.73 and 0.71 for the questionnaires *Pre* and *Post*.

Table 3 In *Pre* questionnaire, obtained CHI for each question

$PreA_1$	$PreA_{11}$	$PreA_{12}$	$PreA_{13}$	$PreA_2$	$PreA_{21}$	$PreA_{22}$	$PreA_{23}$
0.39	0.55	0.51	0.51	0.56	0.57	0.55	0.59

Table 4 In *Post* questionnaire, obtained CHI for each question

$PostA_1$	$PostA_2$	$PostA_3$	$PostA_4$
0.39	0.48	0.37	0.42

Table 5 For $PreA_1$ and For $PreA_2$ variables, median and mode per gender (girls and boys)

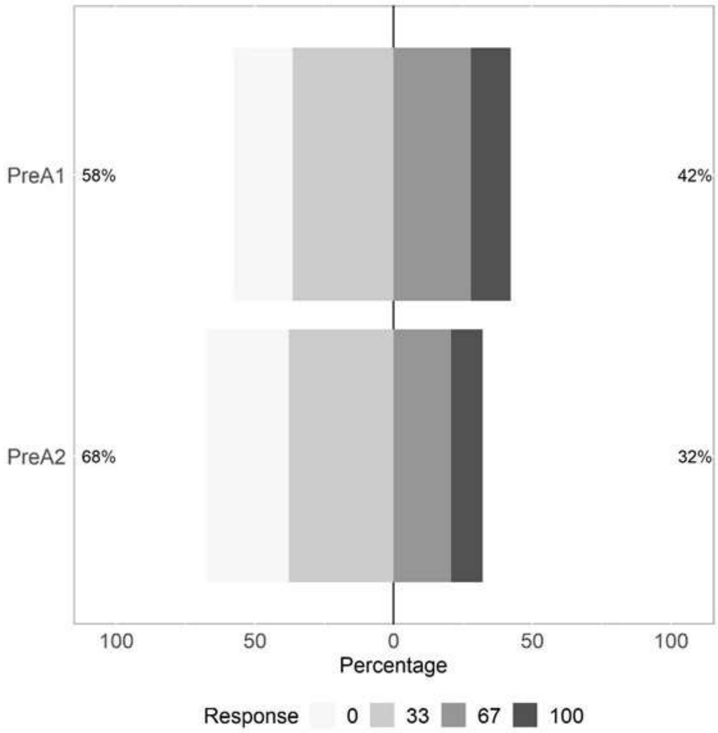
Statiscal Parameter	Gender	$PreA_1$	$PreA_2$
Median	Girls	Low	Low
	Boys	High	High
Mode	Girls	Low	Low
	Boys	High	Very high

Figures 1 and 2 show the percentage of answers to $PreA_1$ and $PreA_2$ in each block (technology and engineering) and band (very high 100%, high 67%, low 33%, very low 0%). Figures 3 and 4 demonstrate in each block and place the answers in $PostA_1$, $PostA_2$, $PostA_3$, and $PostA_4$ for boys and men. Tables 5 and 6 describe the median and the mode for *Pre* and *Post* variables.

Repeating of the experience ($PostA_1$)

The proportion of persons with high and a very high desire to repeat the experience is of a similar magnitude in both blocks, 87.76% and 87.60% for engineering and technology, respectively. This result is aligned with (Perotta 2013; Valderrama 2015; Yip & Kwan 2006) research which argues that the educational video games, if proven to be fun, cause an intrinsic motivation in the individuals, facilitating the understanding of concepts by repeating activities. Using video games, the students advance at their own rhythm and perceive the unsuccessful attempts as chances for learning and undertaking the experience again (Cruz et al. 2016). When separated by gender, according to Figures 3 and 4, a high percentage of boys, 87% in engineering and 85% in technology would repeat the experience. The percentage is also relevant for

Fig. 1



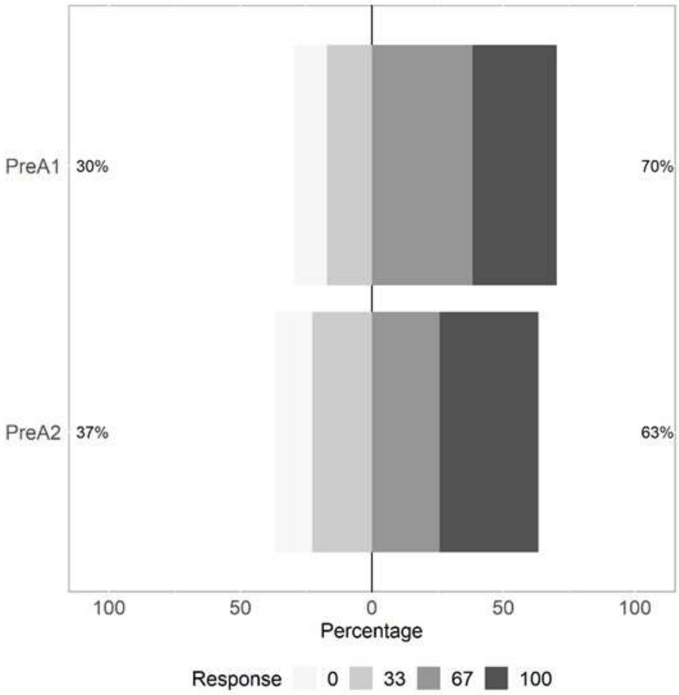
For girls who took part in the experience (85 of 178 students), percentage of answers to $PreA_1$ and $PreA_2$ in each block (technology, engineering) and band 0% (very low), 33% (low), 67%(high) and 100% (very high)

girls, 89% in engineering and 90% in technology. This result is also supported by the significant values of median and mode.

Considering all the above, the desire to repeat the experience is not related to the type of contents, engineering or technology, but instead to some other characteristics of the video game (user-friendly interface, characters' stories and traits, plots, game rules, customization, etc.). This fact is also supported by some studies that suggest that students tend to repeat the experience over and over again until perfection is achieved. This result is dependent on the assumption that the game is suitably designed (Hilliard & Harriett 2017).

With respect to the motivational factors "innovation" and "usefulness", if we observe the results produced by the Spearman correlation, which are shown in Table 7, these factors are the ones that most strongly influence the motivational components related to the desire to repeat the experience. This result is in accordance with studies describing that the use of innovative educational digital technologies can offer great opportunities for learning (OCDE

Fig. 2



For boys who were involved involved in the experience (93 of 178 students), percentage of answers to $\boldsymbol{PreA_1}$ and $\boldsymbol{PreA_2}$ in each block (technology and engineering) and band 0% (very low), 33% (low), 67%(high) and 100% (very high)

2016). In addition, learning strategies must show the utility and the practical applications of what the students learn (Hava et al. 2019; King et al. 2018).

Table 6 For $\boldsymbol{PostA_1}$, $\boldsymbol{PostA_2}$, $\boldsymbol{PostA_3}$ and $\boldsymbol{PostA_4}$ median and mode per block (engineering, technology) and gender (girls, boys)

Statiscal Parameter	Block	Gender	$PostA_1$	$PostA_2$	$PostA_3$	$PostA_4$
Median	Technology	Boys	Very high	High	High	Very high
		Girls	Very high	Very high	High	Very high
	Engineering	Boys	Very high	High	Very high	Very high
		Girls	Very high	High	High	Very high
Mode	Technology	Boys	Very high	High	Very high	Very high
		Girls	Very high	Very high	High	Very high
	Engineering	Boys	Very high	High	Very high	Very high
		Girls	Very high	High	High	Very high

Table 7 Spearman correlation coefficient for the variables $PostA_1$,$PostA_2$ ("innovation"), $PostA_3$ and $PostA_4$ ("usefulness")

	$PostA_1$	$PostA_2$ (INNOVATION)	$PostA_3$	$PostA_4$(USEFULNESS)
$PostA_1$	1.0000	0.4780	0.2672	0.4918
$PostA_2$ (INNOVATION)	0.4780	1.0000	0.3581	0.4083
$PostA_3$	0.2672	0.3581	1.0000	0.3320
$PostA_4$ (USEFULNESS)	0.4918	0.4083	0.3320	1.0000

Learning in a different way ($PostA_4$)

85.71% and 86.05% of persons for engineering and technology felt a high or very high degree that the video game allowed an alternative approach to learning. The value was similar in both blocks. The obtained magnitudes did not seem to be related to the subjects to which the contents were referred nor to engineering or technology. Instead the values connected to other features of the video game, as was the case when measuring the desire to repeat the experience. Breaking the magnitudes down by gender, the values in engineering were 89% and 84%, while in technology they stood at 87% and 85%. The former figure being for girls and the latter for boys. The median and mode values were also significant. These results are in line with research that points out how students feel a great attraction to being taught through educational video games (Eseryel et al. 2014; Padilla et al. 2014; Wang & Degol 2013).

Acquisition of knowledge ($PostA_2$)

Regarding the achieved learning with the video game, the percentage of people with the opinion that a very high or high level of knowledge is acquired was 59.18% and 75.97% for engineering and technology, respectively. The difference in the figures obtained in this variable seems to indicate that there is a relationship with the types of content. Boys reached very high and high levels, 55% in engineering and 81% in technology, compared to 67% in engineering and 72% in technology for girls. The median and mode also had significant values. It is also worth bearing in mind that the majority of people agreed that an increase in learning through video games exists, which is also supported by certain pieces of research (Connolly et al. 2012; Nordby et al. 2016). This result allows us to affirm that the use of our virtual-reality application could be a beneficial educational practice in classrooms in order to enhance learning in the analyzed areas.

Interest in engineering and technological areas ($PostA_3$)

Before running the game, 57.65% of girls expressed a low or very low interest in technology, compared to 30.11% of boys. Regarding engineering, 68.24% of girls expressed that they had a low or very low level of interest, compared to 36.56% of boys. The percentage of girls with levels of interest in bands of low or very low exceeded 50%. This fact, is also supported by the values of median and mode. Once the game had been played, 46.27% of girls showed a low or very low interest compared to 32.26% of boys in technology. With respect to engineering, the girls who stated a low or very low level of interest was a figure of 44.44% compared to 25.81% in the case of boys. In both blocks, the number of girls with a high or very high level of interest had increased, and the interest of boys had decreased. Despite this, the percentage of girls with a low or very low amount of interest was higher than that of boys. The median and mode had significant values in all cases.

Table 8 For the $PostA_1$, $PostA_2$, $PostA_3$ and $PostA_4$ variables, the percentage of people who played the game from the engineering (49 (18 girls, 31 boys) of 178 students) or technology (129 (67 girls, 62 boys) of 178 students) blocks is shown with interest displayed in bands 0% (very low) and 33% (low)

Post variable	Block	Persons	Girls	Boys
$PostA_1$	Engineering	6/49 (12.24%)	2/18 (11.11%)	4/31 (12.90%)
	Technology	16/129 (12.40%)	7/67 (10.47%)	9/62 (14.52%)
$PostA_2$	Engineering	20/49 (40.82%)	6/18 (33.33%)	14/31 (45.16%)
	Technology	31/129 (24.03%)	19/67 (28.36%)	12/62 (19.35%)
$PostA_3$	Engineering	16/49 (32.65%)	8/18 (44.44%)	8/31 (25.81%)
	Technology	51/129 (39.53%)	31/67 (46.27%)	20/62 (32.26%)
$PostA_4$	Engineering	7/49 (14.29%)	2/18 (11.11%)	5/31 (16.12%)
	Technology	18/129 (13.95%)	9/67 (13.43%)	9/62 (14.51%)

The Table 9, shows the correlation of variables, $PreA_{11}$, $PreA_{12}$, and, $PreA_{13}$ with $PreA_1$, it can be observed that there is a low correlation between PreA1-PreA11 and a moderate one between $PreA_1$-$PreA_{12}$ and $PreA_1$-$PreA_{13}$ respectively. The Table 10 shows the existence of a moderate correlation between $PreA_2$-$PreA_{21}$ and low between $PreA_2$-$PreA_{22}$ and $PreA_2$-$PreA_{23}$. Neither in the areas of technology, nor in engineering is there a significant relationship between the knowledge the student had already acquired and their motivation towards that block.

Table 9 Spearman correlation coefficient betweeen the variable $PreA_1$ and the $PreA_{11}$, $PreA_{12}$ and $PreA_{13}$ variables

	$PreA_{11}$	$PreA_{12}$	$PreA_{13}$
PreA1	0.2290	0.3121	0.3994

Table 10 Spearman correlation coefficient betweeen the variable $PreA_2$ and the $PreA_{21}$, $PreA_{22}$ and $PreA_{23}$ variables

	$PreA_{21}$	$PreA_{22}$	$PreA_{23}$
PreA2	0.3104	0.3032	0.2413

Testing of hypothesis. Gender dependence

We implemented a hypothesis test in order to study gender independence more deeply. The p-values ¡0.05 suggest that gender influences $PreA_1$, motivation per technology, (8.345e-06) and $PreA_2$, motivation per engineering, (4.39e-08). From Table 12 it can be noted that, once the game was completed, (p-value<0.05) the interest in engineering and technology depended on gender, but this did not have any impact (p-value>=0.05) on the rest of the variables: repeating the experience ($PostA_1$), learning new matters or reinforcement of acquired knowledge ($PostA_2$), learning in a different way ($PostA_4$). For the variables $PreA_1$ and $PreA_2$ the Fligner-Killeen test with a confidence interval, α, equal to 0.95 yielded the $p - values$ 0.1952 and 0.1453, respectively. The results of this test for *Post* variables are shown in Table 11.

Table 11 For $PostA_1$, $PostA_2$, $PostA_3$ and $PostA_4$ variables, obtained p-value in the Fligner-Killeen test with $\alpha = 0.95$

	$PostA_1$	$PostA_2$	$PostA_3$	$PostA_4$
Engineering	0.403	0.3037	0.6983	0.9822
Technology	0.1028	0.1061	0.4718	0.5708

Table 12 For $PostA_1$, $PostA_2$, $PostA_3$ and $PostA_4$ variables, obtained p-value in the Wilcoxon-Mann- Whitney test with α= 0.95

	$PostA_1$	$PostA_2$	$PostA_3$	$PostA_4$
Engineering	0.4599	0.3334	0.0165	0.9421
Technology	0.1411	0.7036	0.0244	0.4466

The analysis showed that a gender dependence on interest in engineering and technology exists. The results of this study support the research of (Rong & Rounds 2015; Stump et al. 2011) because of the fact that girls' interest rose and, the boys' interest declined in engineering and technology disciplines, after the conclusion of the game. Included in the game was an important relational component among users, emphasizing the productivity and usages of group work. This result is also aligned with other studies that highlight the importance of the relational component in the achievement of active and persistent learning by girls. The outcome of these studies was regardless of the nature or content of task (Goldstein & Puntambekar 2004). Hence, the video game is proven to be a useful tool for awakening girls' interest in engineering and technological matters. As we have already pointed out, teachers and pupils could also benefit from the use of our virtual reality application through its integration into the classroom.

Testing of hypothesis. Age dependence

A hypothesis test was implemented to go into a deeper analysis of of the age dependence. For $PreA_1$ and $PreA_2$ variables, obtained $p - value$ in the Kruskal-Wallis test with a confidence interval α equal to 0.95 yielded the $p - values$ 0.1939 and 0.0267, respectively. The age seems to have an influence, only on $PreA_2$, related to an interest in engineering ($pvalue < 0.05$). However, once the comparison between pairs and the Bonferroni correction were applied, results shown in Table 13, this possibility had to be ruled out. In the case of $Post$ questionnaire, as can be deduced from Table 14, age seems to have an influence on $PostA_1$, repeating the experience, and $PostA_2$, learning new things or reinforcement, for the technology block, (p-value<0.05), which is only confirmed, as Table 15 and Table 16 show, after applying the aforementioned Bonferroni correction, for $PostA_1$, repeat the experience (p-value<0.05).

Table 13 For $PreA_2$ variable, obtained p-value in the U Mann-Whitney test with Bonferroni correction and with α= 0.95

	12 year olds	13 year olds	14 year olds
13 year olds	0.1800	-	-
14 year olds	1.0000	0.0500	-
15 year olds	1.0000	1.0000	1.0000

The percentage of students with very high interest in the repetition of the experience exceeds 60% in both blocks for all ages. However, the results indicate that an age dependence exists only in the desire to repeat the experience for the technology block. In particular, 90.71% of the 12-year old students show a very high desire to play the video game again for this block. Taking this fact into account, an expansion of the detail of the contents could be addressed specifically for these scholars in order to improve their knowledge and learning.

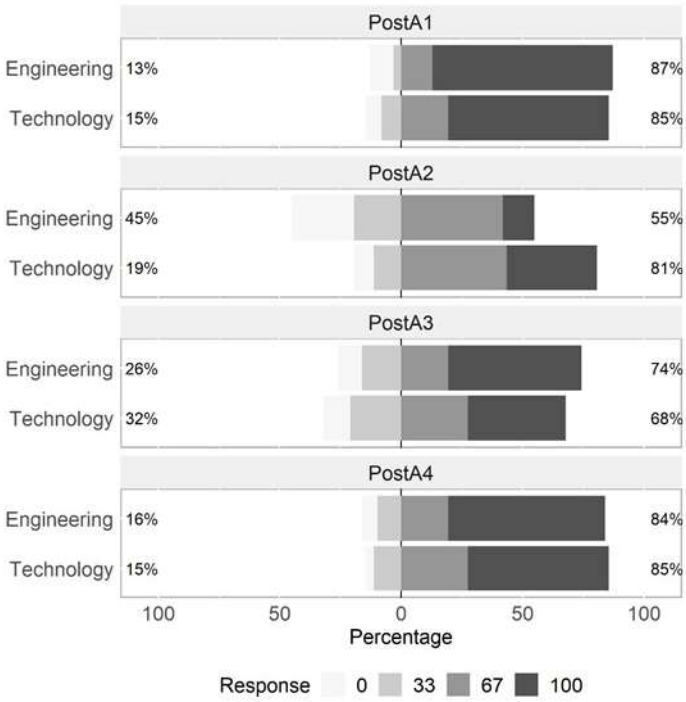
Table 14 In *Post* questionnaire, values for p-value obtained in the Kruskal-Wallis test with α= 0.95

	$PostA_1$	$PostA_2$	$PostA_3$	$PostA_4$
Engineering	0.1336	0.5173	0.3303	0.1089
Technology	0.0074	0.02268	0.6155	0.1523

Table 15 For $PostA_1$, in technology block, obtained p-value in the U of Mann-Whitney test with Bonferroni correction and α= 0.95

	12 year olds	13 year olds	14 year olds
13 year olds	0.0048	-	-
14 year olds	0.0341	1.0000	-
15 year olds	1.0000	1.0000	1.0000

Fig. 3



For boys who took part in the experience (93 of the 178 students), per block (technology (62 students) and engineering (31 students), percentage of answers to $PostA_1$, $PostA_2$, $PostA_3$ and $PostA_4$ in each band 0% (very low), 33% (low), 67%(high) 100% (very high)

Table 16 For $PostA_2$, in technology block, obtained p-value in Mann-Whitney test with Bonferroni correction and $\alpha = 0.95$

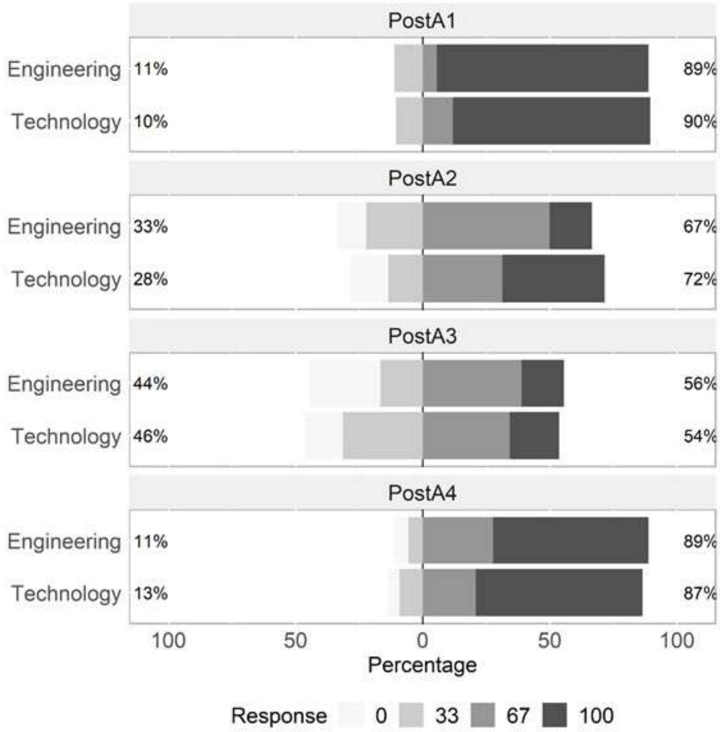
	12 year olds	13 year olds	14 year olds
13 year olds	0.1400	-	-
14 year olds	1.0000	1.0000	-
15 year olds	0.3300	0.1000	0.6700

4 Conclusions and Future Projects

A quasi-experimental study was undertaken with students of secondary education in order to analyze the effects of playing a virtual-reality video game on their learning attitudes towards engineering and technology subjects.

We evaluated the desire to repeat the experience, knowledge gain and the

Fig. 4



For girls, per block, percentage of answers to $PostA_1$, $PostA_2$, $PostA_3$, $PostA_4$, in each bands 0% (very low), 33% (low), 67%(high) and 100% (very high)

interest that the subject arouses in the student, against gender and age.

The *Post* questionnaire scored two motivational factors. The results show that "innovation" and "usefulness" components were those that had higher impact on the desire to repeat the experience. Hence, the educational practices must incorporate new, less theoretically dominant approaches that encourage novelty and originality, resulting in a higher emphasis on the demonstration of the practical utility of the contents.

We also identified through correlation evaluation that interest in engineering and technology subjects did not depend on previous experience in those fields. On the other hand, gender had a major impact, as verified by non-parametric statistical tests. In the case of girls, this interest could be raised through team work. Gender had no significant effect on knowledge gain and the desire to repeat the experience. Age only had an impact on this last factor. This suggests that for certain ages, video games containing more material with novel content and forms of expression could raise learning.

We conclude that the virtual reality video game used in this research as an educational technology is an effective and motivating tool to increase the knowledge of all students, particularly of girls. Accordingly, the video game could be integrated into the everyday classroom by teachers with very good results.

With respect to future projects, we consider the possibility of extending the application, in the short term, to the 2^{nd}cycle of secondary education, incorporating new educational contents. In the future, samples could be separated/divided into different socioeconomic levels. This could be done in order to analyze if there are differences in how the activity can promote the scientific-technological vocations in the students, according to its socioeconomic status.

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